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ABORIGINAL CHIPPED STONE IMPLEMENTS

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CONTENTS

INTRODUCTION

In 1896, the legislature appropriated $5000 to be used by the regents of the University for increasing the state collection illustrating New York aboriginal life, and for preserving such facts as might seem to them of most value. Most of this appropriation has been judiciously used by A. G. Richmond, esq., honorary curator of this department of the state museum, in securing several collections of great value. It was also thought advisable to issue some bulletins of a popular nature, illustrating the antiquities of New York, especially the implements and ornaments of the aborigines. In furtherance of this plan the Rev. W: M. Beauchamp, S. T. D., of Baldwinsville, N. Y., was consulted and his aid secured. He had been engaged for a quarter of a century in this study, and had accumulated a vast amount of available material. His suggestion was that such work might be distributed under suitable heads, each subject complete in itself, but forming a series if desired. The first would be that of the chipped stone implements of New York, and a paper on this is subjoined. A second would be on those polished articles of stone, in which New York is so rich; the paper on this is nearly completed, and will be an important contribution to science. Others might treat on the articles of clay, bone, horn, shell and metal, so abundantly found in the state.

It was thought that, in this way, not only would clearer information be afforded, but that the state museum would be the gainer, by valuable contributions of many things altogether uncared for now. Such has been the result elsewhere, and the local pride of our citizens may confidently be relied upon to make the state collection one unsurpassed. The illustrations are selections from the thousands of drawings which Dr Beauchamp has made, and show both rare and common forms.

For this valuable bulletin the state is indebted solely to Dr Beauchamp to whom its publication has been wholly entrusted. For the admirable work done in increasing the archeological collection, the state is indebted to our honorary curator, A. G. Richmond, president of the Canajoharie national bank, who has for years given his

active and extremely valuable expert service to the increasing of our collections without a dollar of compensation from the state. It is a pleasure to recognize in this public way a service so satisfactory in its result and so unusual in being rendered to the state without salary.

It is hoped that Dr Beauchamp may from the results of his work for the past 25 years give us a series of bulletins which will make his stores of special knowledge available to every student of the subject.

MELVIL DEWEY
Secretary of the University

ABORIGINAL CHIPPED STONE IMPLEMENTS OF NEW YORK

ARCHEOLOGICAL WORK IN NEW YORK

While much has been done by the state of New York in the preservation and dissemination of documents relating to early days, little until now has been accomplished in collecting and arranging those still earlier records, found so largely in stone, which reveal much unwritten history. All early writers describe a condition of things evidently not representative of periods which were then already days of old. Implements and ornaments had changed, arts and history had been forgotten, a new race had displaced the old, as we have taken its place in turn. We can only know what that history and those arts were, by seeking their surviving memorials in the soil.

The state, however, has done valuable service in embodying so much relating to what is called indian history, in many of its publications. Crude as was Mr Schoolcraft's *Report on the Iroquois,* made in 1845, it was a boon to the public, and preserved or suggested much valuable matter. This was notably the case with the several Iroquois dialects, afterwards much enlarged by him. The *Documentary history* and the *New York colonial documents* made other interesting matter accessible. The *Report on the indian problem,* in 1889, wisely placed the Iroquois treaties before the public, although it was great misfortune that the signatures to these were not submitted to an expert in indian names. It would have saved a host of needless errors.

The work of the regents in the same direction has been good as far as it has gone. The annual reports which contain the papers of L. H. Morgan on recent Iroquois implements and ornaments, are yet among the most popular and best preserved. Part of these were afterwards embodied in his valuable *League of the Iroquois,* and were first produced nearly half a century since. The publication of Father Bruyas' Mohawk lexicon, written two centuries ago, was one of the earliest attempts to bring a New York indian language before the public, when systematically arranged. It has since been fully translated. The publication of the explorations and plans of Messrs Hough and Cheney, in the northern and western parts of New York gave prominence to the interesting earthworks in both sections, with occasional notes from others.

In connection with Mr Morgan's literary work he made an interesting collection of modern Iroquois articles for the state museum, and this has been partially supplemented by that made for the World's fair at Chicago, by the Rev. J. A. Sanborn. These might be enlarged. Occasional stone and other relics have come into the state collection by donation, but no systematic or sustained work has been done until that now begun. Individuals have not been idle in making up their own cabinets, sometimes soon dispersed, sometimes remaining, but often far surpassing anything belonging to the state. Notable among these are the collections of O. M. Bigelow, in Baldwinsville, illustrating Onondaga and neighboring counties; that of J. S. Twining, Copenhagen, pertaining to Jefferson county, now in the possession of the state; and those of S. L. Frey, Palatine Bridge, and A. G. Richmond, Canajoharie, so rich in the relics of Montgomery county and vicinity. Many smaller collections of interest might be mentioned.

The early Dutch writers are now available in many ways, and the various historical societies have added much to our knowledge of the aborigines. The Pennsylvania archives and colonial records contain much relating to those of this state, and other valuable material will be found outside of our limits. The recently discovered journal of Arent Van Curler (Corlaer) is a treasure indeed. The *Jesuit relations* have been diligently culled and annotated, and large portions relating to New York are now within easy reach. Valuable notes on local antiquities may be found in such works as Bolton's *History of Westchester,* Hough's *Histories of Jefferson and St Lawrence counties,* Doty's *History of Livingston county,* Young's *History of Chautauqua,* the *Onondaga centennial,* Clark's *Onondaga,* and many other local histories. Some are carefully prepared, forming a good working foundation.

The work done by Mr Squier as yet stands alone as a general account of the antiquities of New York now accessible to the public. Dr Frederick Larkin published a little work in 1880, entitled *Ancient man in America,* which is a careful treatise on the antiquities of the western part of the state. The Rev. W. M. Beauchamp prepared a map for the U. S. Bureau of ethnology, some years since, with de-

scriptive notes of the Iroquois portion of the state, much of it from personal field work. This has since been enriched, and now contains all the reported indian sites of New York, large and small. It is very suggestive in many ways. The Bureau of ethnology has done much here, although its larger fields in the west compel it to leave many things to local efforts.

Philology has had its students. The issuing of Father Bruyas' valuable Mohawk lexicon marked an era in this respect, and Mr J. G. Shea has made valuable contributions from early French publications since that time. Messrs L. H. Morgan and O. H. Marshall did excellent work on the indian names in the western and some other parts of the state. Mr W. W. Tooker in the eastern, and the Rev. Dr Beauchamp in the central part of New York have done much in the same line. Prof. Horsford published Zeisberger's *Onondaga and Delaware dictionary* in 1887, but his journal of his residence at Onondaga still sleeps in the old manuscript at Bethlehem. The late Horatio Hale's *Iroquois book of rites* is an invaluable contribution to our knowledge of Iroquois songs and ceremonies. Prof. Lyman, of Syracuse, has recently taken down a large collection of indian songs, with the accompanying music, and the Bureau of ethnology is steadily at work on the Iroquois dialects. Others might be mentioned.

Colden preserved much in his history of the Five Nations, and the quaint and marvelous history written by David Cusick, the Tuscarora, has passed through many editions. It has recently been republished, with ample notes. Morgan's *League of the Iroquois* is a standard work, but has little to do with prehistoric, or even early historic times.

ABORIGINAL OCCUPATION

The aboriginal occupation of New York was of a varied character and for a long time after it was first visited by man, almost its whole extent was but a temporary resort for hunters and fishermen. Rivers were the first places to attract men, and rifts on these were the favorite spots for camps. Good fishing and fording were important considerations and determined the routes of travelers and the location of many hamlets. The mere abundance of fish and game drew roving

men to some places, and the small supply of the former was a sufficient reason why the Mohawk valley was so little visited until a recent day. For a similar reason deep lakes were little frequented here, unless at the shallow waters near their outlets. The aborigines of New York seldom used the hook and line until after European contact, and the harpoon, arrow, stone fish weir and net were useful only where the water was of no great depth. Large lakes, too, were often perilous places for canoes, while on most rivers they could be employed at any time. Accordingly early relics and camps are most frequent near large streams and small lakes. Where a river was as large as the Hudson in its lower course, camps would be expected only near the mouths of its tributaries, or in sheltered spots; near the sea they would also occur on shallow bays. In the one case the burnt earth and frequent relics, in the other the great shell heaps attest the presence of early man.

Many of the finest articles, however, have been discovered near the old trails, or in low grounds. If lost on a village site in peaceful times, they would have been sought and found with comparative ease. On the road, time could not always be allowed for this, and weeds, brambles and mire might have rendered all search useless.

These visitors came from many directions, and with differing habits, as relics plainly show; but having once been here, there were soon favorite places of resort. In process of time small hamlets were formed, often but the renewal of fishing camps from year to year. The old lodges would be repaired or rebuilt on the same spots, used in the summer and abandoned in the winter. This was the Iroquois practice in the seventeenth century, and in Canada the wandering tribes had a succession of camping places, to which they periodically resorted. Some northern tribes were thus winter visitors in New York. Nearer the sea, many indian tribes as steadily vibrated between the shore and the interior as some of our people do now. The new is ever the old.

When the Iroquois came into New York they brought a change. They hunted and fished, but they were also growers of corn, pumpkins and beans. Although they camped on the rivers, their towns and forts were almost always at some distance from them. It might

be but a few rods, but often it was many miles. They wished not only strong positions, but situations where canoes could not reach them. This was always the case in warlike times, and the position of the town will often show confidence or fear. Their permanent homes also depended to some extent upon the soil, being a corn raising people; and in fact nearly all camps of others as well were placed on a light, and not a heavy soil. Very rarely indeed did other considerations outweigh this. Iroquois villages are thus not to be expected in regions characterized by primitive rocks; a glance at a map showing the indian sites of New York and Canada, will make apparent how much their location was affected by geological conditions.

The Algonquin tribes built palisaded forts in the eastern part of New York, somewhat like those of the Iroquois, and their long houses are reported to have been even longer than those of the latter. Earthworks here, however, were nearly all defenses of the Iroquoian family, and yield abundant earthenware. Some of these are quite recent, and in these are observed suggestions of a knowledge of European articles, soon followed by the articles themselves. These later sites, usually simple stockades, have often done a work similar to that of the Rosetta stone, but in another way. Knowing their age, and finding aboriginal relics on them of peculiar kinds, we are able to give the approximate age of similar articles elsewhere. In this will be found one great advantage of studying some New York sites, an advantage not confined in its results to our own borders.

One important question relates to the Eskimo. It will appear that some articles now used only by them are frequent in the northern part of New York, along with others which suggest their occasional presence. It is well known, also, that they once lived much farther south than now, and it may yet appear that they were sometimes visitors here. Rash conclusions are to be avoided, but so much is known as to call for further light.

It is to be deplored that such quantities of our finest relics are forever lost to the state, but this is a lament in which every part of our land shares. Enough remains to give us some idea of the arts — perhaps of the habits and history — of our predecessors. Although so

many forts and sites have also been obliterated, quite a goodly number have been located and described, and with a moderate farther research it is possible to tell a great deal of the occupation of New York in historic and prehistoric times.

The articles left by the aborigines here have a wide range in nature and origin. In a broad way they may be classed as flaked or chipped forms of stone, those of clay, those of shell, horn or bone, those of metal, glass and wood; and most interesting of all, those of picked or polished stone. This is a simple matter of convenience, for many things in all these have other relations. Fine and beautifully wrought articles may precede those which are rude, or they may have coexisted in the same camp or town. Horn and bone were often used with stone. Metallic articles were of a remote date, as well as recent. Wood was used in every period.

While many rude implements closely resemble those called paleolithic, these are usually surface finds here, pointing to no remote antiquity. In fact quite deep burial often proves no test of age, owing to some well known customs as well as natural agencies. Some implements made of argillite, and much changed by weathering or contact with the soil, although surface finds, are precisely like those occurring in the higher deposits at Trenton, N. J. Thus far none of the ruder articles have been reported at any great depth here, though this is but negative testimony, which farther research may change. Up to the present time polished stone implements have been reported here deepest of all. How reliable the reports are it is difficult to say.

Caches of flint are frequent, commonly composed of broadly chipped stones, rather more triangular than leaf-shaped in form, and nearly alike in size, although this is not always the case. In general they are supposed to be those from which others were to be made, having been deposited either for security or to preserve the temper of the flint. Although not strictly correct, this word will be used for a common material. Many of these simple articles were not farther elaborated, but at once came into use. Others may have been changed into other forms, but this is little more than theory. Their uniformity in size, and their burial in quantities give plausi-

bility to it, and it may well be allowed that they were brought from a distance for purposes of trade, or further development. Quantities of material came here in a still ruder form, which have not been found in caches, and among these were some of the choicer kinds. There are abundant flint flakes in places where they could only have come through the agency of man, and these indicate the arrow maker's temporary home.

The aborigines made but moderate use of the local hornstone, so plentiful in the corniferous limestone of New York, though it is often recognizable in the ruder articles to which it is adapted. At Black Rock in Buffalo, and across the river in Canada, one can easily see where blocks of hornstone were detached and used. Occasionally something of the kind will be seen elsewhere, but most of the material for the finer arrows, knives and spears came from without the state. Among these implements occur jaspers of every hue, white quartz, chalcedony, argillite, schist and sandstone, as well as the finer flints of bluish or brownish grey; yellow jasper was a favorite material, specially for large implements, and it is comparatively frequent in caches. It was probably derived from a neighboring state.

In a very broad way it is well known that the prevailing materials used in any region have a somewhat local character. Through Ohio and much of New York, the grey or drab cherts from the limestone are prevalent, with a projection of this material far southward. In the southern Atlantic states a brownish quartzite or coarse sandstone appears, with finer materials in the mountains. Along the Hudson and in New England white quartz was largely used; and in the northern states of the Mississippi valley an opaque white or pinkish flint was the rule. A characteristic dark hornstone also appears there in immense caches in some places. The beautiful arrows and other small implements of the Rocky mountains and the Pacific slope are also well known, and in other quarters yellow jasper is common. An experienced archeologist may thus often feel sure of the general origin of an article, without knowing precisely where it was found. That is a question of trade or migration.

Material is often a better guide in determining ultimate origin than form. The drills and scrapers of the east are often matched by

those of the west. A few New York arrows rival those of Oregon in size, though not in delicacy. When the stone used is considered the difference is more obvious. Form and material may both aid in determining what people visited New York in early days. In a representative and ample collection from this state, where the locality of the specimen is clearly and correctly recorded, as it always should be, later critical study of this kind may establish facts now unknown, regarding early migration and trade.

Celts, gouges and pestles were often made of local pebbles, but those of basalt and striped slate may show a different origin. Gorgets, tubes, ceremonial stones and amulets often do the same. Native copper implements of course come from afar, and sheets of mica do not naturally occur here. Steatite, as fragments of vessels, is also found abundantly, hundreds of miles from any quarry, and other like things will appear in due time.

All flint implements are not arrows or spears, however much they may resemble them at first sight, and thus a lack of observation and distinction has led to errors. It is not long since Sir John Lubbock said that there were no scrapers here, whereas many forms are abundant in New York alone, some of them precisely like those used by the Eskimo now. They simply had not been observed or reported. A very large proportion of implements termed arrows or spears are really knives. They never could have been shot or thrown with precision, they are so bent or one-sided. Many drills have also been called arrows; and in fact articles often grade into each other, or unite characteristic features. Drill, knife and scraper may appear in one implement, and a writer in early days said of western arrow points, 'if no knife is at hand, they use them also to skin the animals they have killed.' They would answer well.

While there are many gradations, or variations of form, in the flint implements found in New York, few typical examples have been found or described which are without representatives here, unless it be in some massive forms. Farther observation may supply these, and perhaps even others. On the other hand, some notable types appear here as yet undescribed. These should have due prominence.

In chipped or flaked implements the simplest form was that of the knife, which might sometimes be used for a spear, but not often for an arrow-head, unless of unusual symmetry. Many simple flakes were employed for this, the edge being sharply and neatly chipped. Some of these inconspicuous flakes show better workmanship in these edges than large and symmetrical implements, but they seem to have served only a temporary purpose. A knife was wanted; a flake was picked up, to which in a few moments an edge was given; it was used and thrown away. So that it was sharp, little more was required for mere use, but in many cases knives were both large and beautiful. As has been said, in an emergency almost any article might serve as a knife, but there are many special forms. When the surface was bent, as was often the case, knives were probably used also as scrapers, without having the distinct scraper edge. Some agree with Loskiel's description, who says, 'their knives were made in a long triangular shape, the long sides being sharpened.'

ARROW MAKING

In an excellent article on the stone art of the Mississippi valley, (13th *Annual report of the bureau of ethnology*, p. 139-42) Mr Gerard Fowke gives an extended account of arrow making, as practised in different places. Without going into full detail, it may be well to say here that chipping was usually done by pressure or percussion. In almost all cases, a piece of horn or bone, slightly notched, was used as a flaker. The process has been observed by many, for it is not an extinct art, although steel is now often substituted for horn or bone, and glass for stone. Any stone which will admit of a conchoidal fracture, and some which will not, may be used; for large implements, and even for small, a siliceous limestone or even sandstone was often employed. Quartz was used, but some varieties were not adapted for delicate work, while for large implements it was a showy material.

Usually the stone is held in one hand, or placed on wood, buckskin, a blanket, or other yielding substance. More rarely it is held against a stone anvil, and chipped with a stone hammer. Simple pressure suffices in most cases, the bone flaker being set against the

proper points, and small pieces being chipped off by pressing it in different directions. Some hold the stone in the hand, setting the tool at different points and angles, while an assistant gently strikes it. Pincers are sometimes used, and the Klamath indians hold the wooden handle of the flaker under the arm, pressing the stone against the point. A long flat tool, found in Great Britain, was thought a flaking implement by Mr Evans, but the same stone article is here either a scraper or knife.

The time required in arrow making differs according to the size or delicacy of the article to be made. In his account of the indians of Virginia, in 1607, Capt. John Smith said, 'His arrow-head he maketh quickly, with a little bone, of any splinter of stone or glass.' Evans said that the Mexicans could turn out a hundred obsidian knives in an hour, but these were probably only long and sharp flakes, often made at a single stroke. Crook, however, states that the indians of the plains will make from fifty to a hundred arrows in an hour, with a knife for a flaker. These must be rude, however serviceable. A Klamath indian made a complete arrow-head in five minutes, and a Shasta indian took an hour for this. On articles of extraordinary delicacy and size, many days might be employed.

Mr Frank H. Cushing, in his address upon the arrow, at the Springfield meeting of the American association for the advancement of science in 1895, gave an interesting account of his own experience in arrow making. In a boyish experiment he stumbled upon the use of the bone flaker, by which he at once chipped the flint 'in long, continuously narrow surface flakes wherever the edge was caught in the bone at a certain angle.' His experience proved to him 'that paleolithic man, of the French caves at least — that man who is said to have known no other art of working stone than by rudely breaking it into shape by blows of other stones — could not have existed in such primary status of art for more than a few seasons at most.' (See *Proc. A. A. A. S.* 1895. p. 205)

Before he went to the Smithsonian institution or to Zuni, he had elaborated 'some seven or eight totally distinct methods of working flint-like substances with stone age apparatus.' His whole account is worthy of careful study, and to him we are indebted for the know-

ledge of one purpose of caches. From one pebble he had made 'seven finished knife and arrow blades in exactly 38 minutes;' and, 'from obsidian or glass a very small and delicate arrow-point — the most easily made, by the way — in less than two minutes.'

ARROW-HEADS

There are local varieties in arrows, as in other implements, and on some sites one type may prevail to the exclusion of almost all others, but the distribution of all leading types is very general. There are few forms of the smaller chipped implements, from the Atlantic to the Rocky mountains, which may not be matched in form in New York, whether it be arrow, spear, drill, scraper, or knife, the early visitors bringing them from every part. In most cases the finer ones come from a distance, while for the smaller, more common and less valuable, the hornstone of the Helderberg group often sufficed.

Some small forms have been classed as boys' arrows, but there is little reason for this, for they are much too common, and were serviceable in hunting. Many are found in New York less than half an inch in length, and they occur in quantities not over an inch long. Primitive children's arrows were used with a blow-gun.

Arrow making was a necessity to every hunter, but all were not equally skilful, and some would acquire a high reputation, finding their work in demand. A division of labor was inevitable, even in savage life, and Roger Williams described this in 1643: 'They have some who follow onely making of bowes, some arrows, some dishes, (and the women make all the earthen vessels) some follow fishing, some hunting; most on the seaside make money, and store up shells in summer, whereof they make their money.' Some of the finest stone work here, also, was that of an early day, the Iroquois having no fondness for working in stone, and restricting themselves mostly to axes, small arrows and knives. The finest material, also, is not of recent date, but of that period when men were here as hunters and fishers, rather than as residents. This is true of ornamental stone work as well, except in the very recent introduction of red pipestone, and the fine stone pipes of the later Iroquois, made with metallic tools. The stone masks also belong to the historic period.

It is impossible to draw an exact line between arrows, spears and knives, although most of them may be easily distinguished; and it is almost as difficult to classify satisfactorily the varieties of either of these implements. Dr Rau arranged arrow-heads as leaf-shape; convex sided, with truncate base; triangular; triangular, but with indented base; notched at the sides, with convex, straight, or indented base; stemmed, but with various bases; barbed and stemmed. Others have suggested additional groups, but nothing exactly covering all has yet been proposed.

The common form of cached articles in New York is a straight base, straight or slightly concave edges gradually expanding to the full width of the stone, whence longer curved edges contract to the point. These coarsely flaked implements are commonly from four to five inches in length, and sometimes scores occur in one cache. Although usually of the drab, grey or dark hornstone, this is not invariable, nor is the size always the same. They may be found near streams navigable by canoes, but not always close to them. In some cases they are comparatively distant from prominent routes or resorts, but in places favorable for hunting or fishing. They are frequent in New York, and fig. 1 is typical of a large class often used without change. It is one out of a cache of 29 of the same form, and is four inches long, but among the rest were some larger.

Those which Dr Rau called leaf-shaped arrows, seem to be knives as a rule; at least they might have been used as such, and it may be best to refer them to that class. In most cases his convex sided arrows, with truncate bases, seem knives also. The triangular forms, with either the straight or indented base, are true arrow-heads, and these were favorites with the Iroquois, who seldom used others. Their use was not confined to them. Triangular arrows with straight bases are somewhat rare, but the other form is common, and sometimes very slender and beautiful; true arrow-heads, though suggestive of drills. They vary from one to two and one-half inches in length, and on some sites no others will be found. When the Iroquois had brass to use, they retained their favorite form, and the metallic point was simply sheet brass, cut in a long triangle, perforated or not.

To Dr Rau's classification may be added two kinds of bunts, which are divisions of the stemmed arrows, sometimes with expanded

bases; pentagonal and straight sided, double notched, and what is locally known as the shark's tooth form. These might be placed in his classes, although he gives no examples of these forms. Some of them are somewhat local, and beveled arrows may prove to be scrapers.

The various forms of triangular arrows are often called war arrows, and Catlin makes a distinction between war and hunting arrows of a little different nature. (See *North American indians*, 33). He says that the quiver 'generally contains two varieties. The one to be drawn upon an enemy, generally poisoned, and with long flukes or barbs, which are designed to hang the blade in the wound after the shaft is withdrawn, in which they are but slightly glued; the other to be used for their game, with the blade firmly fastened to the shaft, the flukes inverted, that it may be easily drawn from the wound, and used on a future occasion.' If the barbs are the essential distinction, many other forms besides the triangular would be called war arrows.

The wonderful rapidity with which indians send their arrows has been remarked by both early and recent writers, and this argues a corresponding facility in making them. They were not confined to war and hunting, but were largely employed in shooting fish. Father Rasles mentioned this when he was among the Illinois in 1693. When they wanted fish, 'they embark in a canoe with their bows and arrows, standing upright, for the purpose of more easily seeing the fish; as soon as they perceive it they pierce it with an arrow.' This method was noticed farther east, and in Johnson's *History of New England*, 1654, it is said, 'Their Boyes will ordinarily shoot fish with their Arrowes as they swim in the shallow Rivers, they draw the Arrow halfe way, putting the point of it into the water, they let flye and strike the fish through.' Loskiel mentioned the same thing in Pennsylvania, in the last century, 'Little boys are even seen frequently wading in shallow brooks, shooting small fishes with bows and arrows.' Lawson (1714) observed the same thing in the Carolinas, and other early writers refer to it elsewhere. This is one reason for the abundance of arrows along rivers and streams, and this would allow of much larger heads than the usual 'regulation size.'

Triangular arrows with concave bases are widely distributed, and in New York their chief distinction is in material and breadth. In

Europe they seem rare. Sometimes they are almost equilateral; at others nearly as slender as many perforators. They are usually neatly chipped and thin. Fig. 2 is a small example, about as broad as long, being an inch in extent. It has a concave base, and is of common flint, slightly mottled. This comes from the Seneca river, where it is a frequent form. It is sometimes much smaller. Fig. 3 is of brown flint from the same stream. In this, however, while the base is more deeply concave, the lateral lines are slightly convex instead of straight, and the width exceeds the length, being one and three-eighths inches. Fig. 4*a*, a still broader form, seems a true arrow, and yet there are reasons for thinking it a knife. It is of common dark flint, and is one and one quarter inches wide. Fig. 4*b* is an extreme form of this, from Cross lake. It is of an obscurely banded drab flint, and the width is one and eleven sixteenths inches, more than double the length, if we call it an arrow, but its proper place seems with the knives. Fig. 4*c* shows the other extreme of this somewhat rare form. In this all the angles are a little rounded.

Three early forts, near Baldwinsville, have afforded some of the finest examples of the straight sided, slender triangular arrows, varying from one and one quarter to two and one half inches long. From one of these, a stockade on the north side of Seneca river, come both broad and extremely slender forms, with all intermediate grades. Fig. 5 is one of these, one and one quarter inches long, and of dark flint, proportionally quite as broad as those so frequent elsewhere. Fig. 6 is of light drab flint, and is two and one half inches long, the utmost limit technically allowed for arrow-heads. It will be seen that an inch more would add little to its weight, or resistance to the air. Fig. 7 is of the same material, and from the same place. It is two inches long, and another almost as long is very much narrower.

An Onondaga stockade, occupied about A. D. 1600, has this smaller and broader form, but with few examples. It occurs a little later in time, in common flint, in a stockade a mile south of Delphi, but is not as neatly chipped. An Onondaga stockade south of Pompey Center, apparently occupied about 1640, has the same form and material. Fig. 8 is an example, one and one eighth inches long. Some are smaller than this. Most of these later specimens are small,

and have a deeply indented base. They occur on Indian hill in Pompey, the site of the Onondaga town which Father Le Moyne first visited in 1654. Fig. 9 is a beautifully mottled one from Watervale, in the same town. It is two inches long, and is exceptional in material, as most of these are of common flint.

In the early Mohawk towns the same favorite Iroquois arrow appears, but in a ruder form. Fig. 10 is a curious example from the earthwork in Minden, near Fort Plain. This work seems to have been one of the earliest triad of Mohawk forts, occupied respectively by the three clans of Turtle, Bear and Wolf, and having suggestions at least of European contact. Squier's statement that European articles have been found there, seems premature. This arrow point is of grey flint, one and one quarter inches long, and may be unfinished, as it is flat on one side, and much ridged on the other. Fig. 11 represents another of the same material, and much like the last, except in having a lower ridge and deeper base. This comes from a Mohawk town east of Wagner's Hollow, which has afforded some of the most remarkable relics of the early historic period. Although usually of common flint, fig. 12 shows a very pretty white one from Baldwinsville, which is not only a good example, but is very finely serrated.

There are distinct varieties of the triangular arrows, and fig. 13 represents one of the rarest of these from the double walled earthwork, three miles southeast of Baldwinsville. It is of a beautifully variegated and lustrous flint, with a distinct groove in the center of each surface, tapering from base to point. The base is much indented, though not as deeply as in some, and the length is two and one eighth inches, with convex edges. The locality is of importance, as showing this to be an Iroquoian form. Fig. 14 shows another of these from Cross lake, two and one half inches long, which is very fine, and of a light bluish grey flint. Other fine examples might be given, for though somewhat rare, it is widely distributed.

Another variety, in which the edge presents a double curve, is locally called the shark's tooth form. Jones, in his *Antiquities of Georgia*, calls most triangular arrows the shark's tooth form, but in New York it is restricted to a peculiarly curved outline. Fig. 15 is

an extreme form of this, made of common flint, one and three quarters inches long. It is remarkable for its obtuse barbs. This was found on Onondaga lake. Fig. 16 represents the typical form, with gentler curves and sharper angles. It is a large specimen from Ithaca, of dark flint, and two and one quarter inches long. Many differ hardly at all from this except in size. Fig. 17 is a slender form from Brewerton, of common flint, two inches long. They are rarely as slender as this, but many intermediate varieties occur, none of which have slender barbs. Good examples seem almost peculiar to New York.

Notchless pentagonal arrows are moderately distributed, and occur in several materials. Fig. 18 is one of common flint, from the town of Van Buren, and has angles somewhat rounded. It is quite flat, and one and three quarters inches long. They are usually quite as broad as this, though slender forms occur. A ruder and more massive one, of the same size and outline, comes from Baldwinsville. It is made of a piece of common hornstone, which unites the light clay color and the dark drab tint. They may be either arrows or knives.

The name of bunt has been adopted for a class of stemmed stone arrow-heads, with broadly rounded or obtusely pointed ends. The term was first used in Missouri, and while Mr A. E. Douglass, of New York city, has 753 Missouri specimens in his collection, he reports none from this state. They are frequent farther south and southwest, and seem here most abundant on the Seneca river. In outline they often have the scraper forms, and are sometimes confounded with them, but the class will hold good. To this day the Onondagas use blunt headed arrows made entirely of wood, as they probably always did. Sometimes those of stone seem to have been merely broken arrows, long ago recut for use, as in fig. 19, from Seneca river. Of course this might have been used for digging purposes, like longer ones of this form, but it seems too short for this. In this specimen there is no perceptible difference in the flaking, as though it had a secondary use. It is one and one half inches long. Fig. 20 shows a longer and straighter form, made of light grey flint. This is quite thick, and about one and three quarters inches long. Fig. 21 is a typical form, of which there are many examples. It is

of common flint, and is one and one half inches long. Most of these are from Onondaga county. The same form often appears in scrapers. Fig. 22 can hardly be assigned any other place, although too long and heavy to be strictly called an arrow, being two and three quarters inches long, and very coarsely chipped. It is of common flint, and occurs on the Seneca river in smaller sizes. As an arrow it might have been used to stun fish.

Fig. 23 is a fine arrow of the bunt form, quite flat, and with a finely rounded edge. It is one and three eighths inches long, and is made of a fine brown flinty sandstone. In this the stem expands at the base. Fig. 24 is even finer, and is of dark blue flint, about one and one quarter inches long. It differs from the last in having distinct barbs. Fig. 25 has a simple rounded stem, and is a beautiful specimen, made of light grey and lustrous jasper. It is from Cross lake, and is nearly one and seven eighths inches long. This is more properly a scraper, for though it is neatly chipped all over both sides, yet one side is much the flatter, and the edge is cut at the usual angle. It may be considered an intermediate form. A large proportion of the bunts on Seneca river have the rounded end, but some are angular. They are quite variable.

Among the stemmed but notchless forms are many having a suggestion of barbs, and of the kind which Catlin called hunting arrows. This projection, when not carried below a horizontal line, is now called a shoulder, and is a frequent feature. The edges may be straight or curved, and they are so common as scarcely to require illustration. Fig. 26 is a good typical specimen, made of light grey flint, and one and seven eighths inches long. This is from Cross lake. An infinite variety will be found in this simple form, produced by variations in length, breadth, and proportion of parts. Fig. 27 is a very odd example, of yellow jasper, suggesting both the pentagonal and bunt arrows, and having deep notches. A little central point also suggests the drill. It comes from Tonawanda and is but little over an inch long. Fig. 28 is still more curious here, being more like extreme western forms than those of New York. It is very small, too, though others here, of a different outline, are less than half the length of this. It might be described as a narrow and a

broad triangle, united by their bases. It is of flint, one and one quarter inches long, and is said to have been found on Grand island, in the Niagara river. Fig. 30 is a very small and pretty arrow of yellow jasper, three quarters of an inch long, and comes from Amboy, west of Syracuse. Yellow jasper is a common material for small arrow heads.

Fig. 31 represents a very common form. This is of white flint, two and one eighth inches long, and comes from Brewerton. It is neatly chipped, and has a slightly expanding base. There are many small and often good specimens of this form, usually quite slender, and made of the nearest hornstone, but fine examples occur on most indian sites, except those of the Iroquois. Beveled arrows are commonly of this form.

Among the notched or shouldered arrows, of every variety, more or less occur which are of a spiral or twisted form, but whether this came from design may be a question. The indians were aware of the advantages of a rotary motion, and learned to rifle smooth bore guns very neatly for themselves. Loskiel said, 'Many of the Delawares and Iroquois have learned to make very good rifle barrels of common fowling pieces, and keep them likewise in good repair.' On the other hand, the triangular Iroquois arrow-heads, whether of metal or stone, were made as flat as possible. Obviously, a rotary motion was not always desirable in the woods, and to this day the Onondagas do not feather their own arrows, though they will do it for others. Accordingly, as the spiral twist is the exception rather than the rule with stone arrow-heads, and is quite as frequent in knives and spears, this feature is to be ascribed to the first flaking of the material, rather than to design. It may be observed that in the picture of the battle on Lake Champlain in 1609, the indians on both sides have feathered arrows, as is the case in the picture of a Susquehanna warrior made about the same time, and this might be thought the idea of the European artist, rather than the fact, were we not told elsewhere how the southern indians affixed the feather. When required, the Onondagas feather their shafts very simply and neatly. The shaft of the feather is split, one side only being used. The anterior part of this is stripped and bound on the arrow shaft,

pointing toward the notch. Then the feathered part is reversed, given a slight twist, and bound firmly at the end. As this spiral twist is said to be purely American, some have claimed that thence came the idea of rifling gun barrels. This feature, however, appeared in Europe as early as 1520; even earlier as regards the mere groove.

Another arrow form is not distinctly notched in the usual way, but has an angular indentation on each side. Fig. 32 is a good illustration of this. It is of common flint, one and one half inches long, and was found on the Seneca river. Such arrows are quite flat, and might easily have served for knives. Fig. 33 is of the same form, but a little larger, being one and three quarters inches long. It is of brown flint, and was found on Oneida lake. These are typical of many others, but some are proportionally very long. Fig. 34 is an intermediate form, with curving instead of straight outlines, and this also is typical of a large class, many of which are not more than half this length. It was found on the Seneca river, and is one and five eighths inches long. The material is that whitish flint, so commonly used in some parts of Illinois, and which is frequently seen in arrow forms in New York.

Some parallel sided angular arrow-heads are both remarkable and rare. Two of the best specimens of these were found on the Seneca river, more than ten miles apart, and no one can doubt they were made by the same hand. Both were picked up by the writer, one being at first thought a broken arrow, as it lay on the ground. Fortunately something about it arrested attention, and a slight examination revealed its great value. For comparison, as well as on account of their unique character, both are represented in figs. 35 and 36. They are quite thin, one and one eighth inches long, angular and straight sided, and are of drab flint. The notch on each side distinguishes them from some other forms. One much like these was found at Newark Valley, of the same material, but slightly larger. It differed in having a distinctly concave base. Fig. 37 has a resemblance to these also, but is much larger and ruder, although thin. It is of a grey flinty limestone, and was found on the east side of Skaneateles lake. The length is two inches, and the width but very little less. Fig. 38 shows one from Herkimer county, of common flint, and

one and one half inches long. It is not as symmetrical as the parallel sided ones mentioned, and it has a notch in the center of the base, besides those in the sides. There are other examples which are much less striking than these.

Fig. 39 is of yellow jasper, with curving edges, and somewhat thin. It is an inch long, and has long barbs, a feature not common here. It has the needle-like point, found in many arrow-heads, but usually more distinct than in this. This feature is shown in a broad way, though by no means typical, in fig. 40, which is of black flint, one and five eighths inches long, and from the Oswego river. This has long barbs, though shorter than in some imperfect specimens, such slender projections being peculiarly liable to fracture. Its general character is more like articles from Ohio than New York. Fig. 41 is the most remarkable for material, being a shark's tooth, perhaps a fossil, one and one half inches long. It has been deeply and narrowly notched, but is otherwise unchanged. It may be a memorial of the Iroquois wars with the Catawbas and other southern indians, or it may be of an older day, for, although found near an historic Cayuga site, its age is uncertain. It was found in a grave near Union Springs, on the east side of Cayuga lake, by Mr S. L. Frey of Palatine Bridge, whose account may be quoted. 'The burials at this place were very numerous, and judging from the state of the bones, older than the coming of the whites, unless a single glass bead which I found there, would seem to indicate white trade. At this place, associated with many small shell beads, or rather shells used for beads, was the arrow referred to. It is perfect, and just as it was in its original state, except the two slits which have been cut for fastening it to the shaft. The enamel is as hard, glassy and perfect as ever, and it is really a unique specimen, as far as my explorations go. I think similar ones were used by the southern indians.' The locality is one where there were early and recent cemeteries and villages, but on the whole the grave was probably comparatively recent. Perforated fossil shark's teeth were used as ornaments in Georgia.

A few double notched arrows appear, but this feature is more frequent in the spears, where the advantage would be greater. In

fact these are so large that they might well be called a small form of spears. Fig. 42 is one of grey flint, and comes from Brewerton, where spears of the same kind are found, and it differs from them only in size. It is two and one half inches long, one corner of the base being broken off, so that but one notch remains on that side. The notches are neatly made. Fig. 43 is a curious one from Onondaga lake, of the same length, and of common flint. It is much thicker than the last, and has a narrower base and broader notches. A similar base appears in one from Seneca lake, though somewhat wider. The latter may have a more definite claim to the title of arrow, being one and seven eighths inches long. It has a rounded point, and the notches are neatly cut. This is the smallest of these thus far reported.

The ordinary notched or shouldered arrows, the most abundant of all, occur in several varieties. Those with widely expanded bases are frequent in central New York, and are usually quite thick, although not invariably. Fig. 44 shows one of blue flint, from Nine Mile creek, in Onondaga county. This has a base one and one half inches wide, making the three sides nearly equal. So broad is the point of the next that it might be classed as a bunt. This is shown in fig. 45, which is of common hornstone, one and one quarter inches wide, and with a concave base differing a little from the last. In both of these the broad wings of the base are notable features, well brought out by the deep notches of the lateral edges. Fig. 46 represents another frequent form, which may be thin or thick, long or short. This one is of a variegated drab flint, one and one half inches long, which is a very frequent size. It comes from the Seneca river, and differs from the last in being longer, having shallower notches, and a straight base. There are many beautiful examples of this form, and it was well adapted for preservation, specially when thick. It may be observed that many such arrows are thickest toward the point, thus allowing the thinner part to be inserted in the shaft.

Fig. 47 is a more slender form, also somewhat common, though not usually as fine as this. It will be seen that most of these are simply notched triangular arrows, many of them quite as thin as in that characteristic form. This specimen is of drab flint,

one and three quarters inches long, and was found at Baldwinsville. One a little broader, but only one and three eighths inches long, was found at the same time and place. Some smaller and thicker forms are less deeply notched. They are among our most beautiful arrows.

It may be remarked that some eccentric forms were probably personal, or at least tribal, used to show ownership or nationality. It has been pointed out that two arrow points already figured, were made by the same man, so rare is the form, and so close the correspondence. If stolen or lost for a time he would have no difficulty in identifying his property. This extended into a national feeling. As we have seen, in recent times the Iroquois used the triangular arrow almost exclusively. If other forms were then as characteristic of other nations, the form of the arrow used would indicate the actors in any sudden raid, and these often had a pride in making themselves known. There are several instances in early history, where tomahawks or war clubs were used for this purpose. Thus, a Canadian indian, on a scout on Lake George in 1690, saw the English and Iroquois making canoes. Failing to make a prisoner he 'suspended three tomahawks within sight of their cabins, indicating to them that they were discovered, and that he defied them to come to Montreal. These tomahawks are a species of club on which they carve figures, and in that way manifest their wishes.' In speaking of some depredations committed in 1695, near Montreal, the French said, 'These blows were struck by some Mohawks and Oneidas, as we discovered by their tomahawks, which they left sticking in the ground, according to their custom.' It will be readily seen that a warrior who wished to be renowned might adopt a distinct form of arrow as his own, and be allowed a certain informal copyright. His arrow would prove his deed, whether in hunting or war. This, of course, could not be carried out to any great extent, and yet will account for some exceptional forms. Personal taste may well be allowed a place, but in a few instances a higher purpose may have been connected with it, and there is no doubt at all that little peculiarities clearly distinguished the implements and arms of various nations. Among the remaining Iroquois the snow snakes of the Onondagas and Senecas might seem precisely alike to the casual observer, and yet they have perma-

nent distinctions. The same considerations have their application to very many other things. Closely related as they were, each Iroquois nation had its own fashions.

Fig. 48 is not common, and the work is somewhat coarse. The basal line is also convex, a rare feature in this form, unless there is a central notch or double curve, as in some of the following. The lateral notches are also deep, and the implement is beveled. It is of brown flint, one and three quarters inches long, and was found on the Seneca river. Fig. 49, from the same place, is by no means rare, though quite variable. This is of brown flint, one and one half inches long, and with a basal width of one and three sixteenths inches. The notches are quite deep, and the cutting edges convex. The base is hardly as concave as in most of this form, which is of wide distribution, extending far to the south and west. Fig. 50 is of the same general form, but has a hollower base and straighter edge. This is of brownish white flint, and comes from Brewerton, at the foot of Oneida lake, for ages a favorite resort of the aborigines. It is one and five eighths inches long. Fig. 51 is of dark brown flint, one and seven eighths inches long, the base being one and one quarter inches wide. This is also concave, and the implement is thick. It comes from Onondaga lake. Fig. 52 is another, made of common hornstone, with a fine concave base. The full length is two and one quarter inches, and the base is one and three eighths inches wide. It was found at Baldwinsville, and the form is rather frequent in that vicinity. A much smaller one, with some peculiarities, comes from the same place. It is but little over an inch long, and the base is much deeper and more indented. This form even occurs in quartz, but with less elaboration.

Some of the smaller arrow-heads have peculiar features, and slender ones, with one sided bases, occur occasionally. Fig. 53 is a good illustration of these. It is of drab flint, one and five sixteenths inches long, and quite inequilateral in every way, so much so as to make it a question whether it should not be called a very small knife. They are hardly common, and those figured here are from the Seneca river. Fig. 54 is another of these, of the same material, but proportionally much wider than the last. It is but little over an inch long,

and browner than the one preceding it. Fig. 55 is of the same brownish hornstone, but perhaps more like limestone, and less neatly chipped than the others. It is also more symmetrical. It is one and five sixteenths inches long. The first may be considered extreme forms of these.

Fig. 56 has a double curved base, angular in the center, and is of an obscurely banded dark blue flint, rather thick, and two inches long. It comes from Seneca river, where there are many modifications of the form. Fig. 57 is from Wood creek, east of Oneida lake, an early thoroughfare in historic times, but less so at an earlier day. It is of common flint, two inches long, and has the double curved base more deeply notched than the last. It has also a much narrower and more rounded base, this being less wide than the main part of the arrow. They are sometimes distinctly barbed, rather than shouldered. A beautiful one of variegated brown flint, two inches long, comes from near the Seneca river.

Fig. 58 is from the same vicinity, and is of a light brown flint, with two black bands appearing on one surface. It is quite thin, and is one and one quarter inches long, the base being seven eighths of an inch wide, this being the broadest part. The form is quite odd in several respects, being somewhat angular, and with straight converging sides. Fig. 59 is another broad and peculiar form, less prominently notched than the last, but almost as nearly triangular. It is of drab flint, and quite thick. The length is two and one half inches, and the breadth one and five eighths inches. It comes from the Seneca river, and might be called either arrow or knife. It would be rather heavy for the former, unless used at close quarters or in shooting fish. It must be remembered that much of the primitive forest archery was at short range.

Fig. 60 is much like the last in outline, though with a deeper base, like some preceding forms. It is small for so neatly made an implement, being considerably less than an inch in length. This is of light colored flint, and is also from the Seneca river. The surface is even, and the outline very symmetrical. Fig. 61 resembles the last, but is a ruder specimen, being quite thick and ridged through the center. It is of dark flint, one inch long. This form is quite abundant

along the Seneca river, and varying examples will be given later. Although small, they are quite large enough for effective use.

Fig. 62 is a very rare and beautiful arrow-head, made of light bluish flint. The point has been slightly broken, and was acute, making the original length one and one half inches. It is straight but not parallel sided, the base is deep, and the notches so much enlarged within as to give both base and sides the appearance of approaching barbs. Its most striking feature is that of expanding above the notches, until half way between these and the point. The surface is flattened. This unique specimen came from the Seneca river, which was a favorite early resort, both for its own advantages, and as being the outlet of so many lakes. At every rift are found camps and hamlets of varying age and character, and these rifts are quite frequent in its long course, which was easily navigable by the indian's light canoe, as it has since been traversed by the larger vessels of the white man.

Fig. 63 is a small, but prominently shouldered arrow-head of opaque white flint, found opposite Three River Point, where the Oneida and Seneca rivers unite to form the Oswego. The junction of two such important streams made this a natural stopping place, and many arrows and spear-heads of similar material have been found there. This is but one and one eighth inches long, and several have been collected of similar form, but usually smaller. In this all the outlines are concave, except the lowest of all. Fig. 64 is another of these, from the Oswego river, and but one inch long. It is of dark blue flint, and every way more slender than the last. The base is wider, and it was distinctly barbed, but one of the barbs has been broken. Fig. 65 is of drab flint, and was found at Baldwinsville. It is but seven eighths of an inch long, and has a deep and expanded base, but has a strong general resemblance to the preceding. On comparing these with articles from other places, this may be regarded as a rare form. Neither Rau, Abbott, nor Fowke give any figures closely resembling it.

Fig. 66 has been referred to before, among those arrow-heads which have concave bases. It is a fine example, with a deeper and more angular base than usual, while it is also quite small. It is of

drab flint, one inch long, and quite thick. It was found on Seneca river.

Fig. 67 is a beveled arrow of drab flint, two inches long, and from the same locality. Besides the bevel on each lateral edge, the basal edge has also its bevel, which is not a common feature, and it is more slender than is usual with implements of this type and size. These are rarer here than farther west, and suggest scrapers. Those which are large enough to be classed as spears are sometimes quite slender. While the elaborate work distinguishes them from the broad flaking of the under side of the common scraper, it is difficult to assign any other use to the characteristic edge. At the same time, this edge is sharp enough for many cutting purposes, the bevel resembling that of a chisel.

Fig. 68 is a rare form from Wood creek, east of Oneida lake. It is of common flint, one and seven eighths inches long, indented but not notched, and presenting curved lines in every part. Except in the expanded base, it is much like one of the finest forms of knives, and might have been used either for knife or arrow.

Fig. 69 is a fair example of those arrows which end in a needle point, though this point is scarcely as slender as in some others. This is of drab flint, one and three quarters inches long, and was found at the mouth of Chittenango creek, where it enters Oneida lake. Such specimens are rarely perfect, but they often preserve the slender point, even when broken elsewhere. This curious feature suggests a union of the knife and drill. It has scarcely attracted attention elsewhere, nor are good examples frequent in New York. The points are too neatly worked to have been accidental, and they are too delicate for any rough usage, thus leaving their purpose to be conjectured.

Fig. 70 is quite another type, having convex edges and a slender base. It is of drab flint, two and one quarter inches long, and may have been either arrow or knife. It was found not far south of the Seneca river. The point is rounded, which is its main distinction from the next. Fig. 71 is not quite two inches long, and is of black flint, with sharp and thin edges all around. It is found in the same vicinity, and the same remarks apply to its use. This is straight and

symmetrical, but in some examples the surface is so distinctly curved as to leave no doubt of their being knives. This is true of other forms.

Fig. 72 is an unusual form of the triangular arrow or knife, having a truncate base and convex sides. It is of common flint, one and one quarter inches long and very thin. This comes from Owego, on the Susquehanna, and is quite rare in this state, and probably elsewhere. Neither the truncate base, nor the convex edges are features of our triangular arrows. Usually the base is indented, and the sides straight, but in larger implements both features may appear, and often do, separately or together.

Fig. 73 is a broad, notched, and finely serrated arrow-head of dark flint, from Seneca river and one and seven eighths inches long. Distinctly serrated flints are quite rare in New York, but frequent farther west and south. Those most distinctly serrated, and preserving the knife or arrow form, have been considered saws, and might well have been used as such. This was Evans' view of those found in Great Britain, but it has met with but moderate endorsement here. This feature, however, is so conspicuous in some that they will hereafter be referred to as saws in this paper, simply as a possible use.

Fig. 74 is a thick stemmed arrow-head of dark flint, two and one half inches long, and found on Seneca river. It is distinctly shouldered, and has a convex base and edges. The form is quite common. Fig. 75 is of quite a different character, resembling some before figured, but with a narrower base, the lateral edges also presenting two nearly straight lines. This is two and one eighth inches long, rather thin and of dark common hornstone, from the same vicinity. Fig. 76 is quite curious in form, although one of the stemmed arrows with expanding bases. It is quite thick, while at the same time slender in outline, and is of dark flint, two inches long. The work is rather coarse.

Fig. 77 is almost unique, while having the leading features of some preceding forms. It is one and one half inches wide, and but one and one quarter long, broadly shouldered, and with a concave expanding base. The straight edges meet at an obtuse angle. It is of light colored flint, rather thick, and like the last, comes from the

Seneca river. The base has a double curve. It is a fine example of a rare form.

Fig. 78 shows a frequent form which is often rude. This, however, is neatly made, and is ridged on both sides. It is of brown flint, two and one quarter inches long, has a long stem, and is from the same place. Such forms are often flattened on one side, and ridged on the other. Fig. 79 is a small arrow of drab flint, rather flat and a little curved. It is but seven eighths of an inch long, stemmed and broad. This is also from the Seneca river. Triangular arrows are found there even shorter than this.

Fig. 80 represents one of the commonest forms, and one very variable in size, material and finish. They are usually coarsely made, and probably were rapidly finished and little valued. This one is of black flint, and is one and one half inches long. They are often much smaller, and on many sites scarcely any thing else occurs. In assigning these small points to boys, the fact has been overlooked that the efficiency of an arrow-head was not in proportion to its size. Its office was simply to open the way for the shaft which propelled it, and for this purpose it needed only to be sharp and slightly larger than the shaft itself. Thus Verrazano, in 1524, found the Long Island indians using arrows tipped with fish bones, while farther east many had them tipped with stones. In an account of New England indians, written in 1620, it is said, 'For their weapons they have bowes and arrowes, some of them headed with bone, and some with brasse.' Capt. John Smith said that the indians of Virginia had many arrows headed with bone. Others used sharp stones, turkey spurs, or birds' bills. The Sasquehanocks whom he met in 1608, had arrows a yard and a quarter long, 'headed with flints or splinters of stones, in forme like a heart, an inch broade, and an inch and a halfe or more long.'

It will be observed that the writer differs from some on the true distinctions of arrow-heads, while following the usual classification as a matter of convenience. The small points were not made merely for children, but were useful to men. Length is a less essential feature than breadth, and some long and slender forms may have been used as arrows, where shorter and broader forms were not.

Obviously, half an inch added to the width, or a doubling in thickness, would have produced more resistance in the air than a much greater increase in length. At the same time, for certain purposes and where the range was short, as in the shooting of bears or fish, neither an increase in weight or breadth would have been a disadvantage. In a general way, more than one form would be found in the quiver, even while a special object was kept in view. Sir John Franklin unexpectedly met a party of Eskimo in 1825. These at once changed their hunting arrows for those of war, showing that they were well supplied with both. This distinction of kinds probably went much farther. The hunting arrows themselves were adapted for different kinds of game.

Fig. 81 is another of these small arrow-heads, made of dark flint, and one and one quarter inches long. Fig. 82 is a little smaller, being one and one eighth inches in length. Fig. 83 is a fine arrow of white quartz, two inches long. All these are from the Seneca river, and others of these simple stemmed forms present many variations.

Fig. 84 is a large and broad arrow-head of drab flint, from Onondaga lake. It is quite thin, and is two and one quarter inches long. This would have served quite as well for a knife, and is notched and well worked. Fig. 85 is from the same vicinity, and is more distinctly notched, and also much narrower. It is of blue flint, and is two and one eighth inches long. The base is slightly wider than the blade. This form is quite frequent in larger sizes. Fig. 86 is a very neat notched arrow-head, from the same place. It is made of common hornstone, and is one and three quarters inches in length, being both thin and symmetrical. Fig. 87 is quite curious, and comes from Oak Orchard, on the Oneida river. It is made of olive slate, of uniform thickness, and the edges alone are worked, much like a scraper. Arrows made of stratified material are hardly rare, but slates like this are seldom seen adapted to such uses.

Fig. 88 is a large barbed arrow, nearly two and one quarter inches in length, and made of a bluish drab flint, variegated with white quartz. It was found, with others of similar material, near Three River Point. The barbs are well preserved, and the work is good. Fig. 89 is a small notched arrow of brown flint, one inch long, and

comes from Seneca river, where many of this form have been collected. Fig. 90 is another neat little arrow-head from Onondaga lake. It is of light brownish drab flint, one and one eighth inches long. It has a wide base, and is almost barbed. Fig. 91 is a rare and beautiful form of the angular arrow-heads with parallel lateral edges. It is quite deeply notched, and differs from those already figured in the graceful concave sweep of the broad base. This unique article, of dark flint, and about one and one quarter inches long, was found at Newark Valley, Tioga county.

Fig. 92 is a small beveled arrow of dark flint, from the west shore of Cross lake, and is waterworn. Many articles are found in this condition in streams and on shores. This has a stem broadly indented on three sides, and is of unusual form for an article of this description. It is one and three eighths inches in length, and like all of its class, might easily be considered a form of scraper.

Fig. 93 has also a concave base, but much narrower. It is shouldered, and has a finely serrate edge, of irregular outline. The form is that of many Ohio specimens, and it is of a dark flint, one and one half inches long. It was found near Three River Point. Fig. 94 shows a very neat and unusual form of the notched base arrows, but it has the three conspicuous concavities which mark the last two examples. The point is broadly rounded, and while the length is but little over an inch, the width is seven eighths of an inch, from point to point. It is of common flint, and was found at Newark Valley. Fig. 95 is classed as an arrow-head, but is much like the flints so often found in caches, although smaller than most of these. It is of a light brownish grey flinty limestone, and is quite thin and sharp. The length is two and three eighths inches, and it was found on the Seneca river. Although this form, being symmetrical, is popularly classed with the arrows, its proper place seems to be among the knives.

Fig. 96 is a pretty stemmed and shouldered arrow-head of red jasper, from Baldwinsville, and is but little over one and one half inches in length. While articles of yellow jasper are quite frequent in New York, those of red jasper are rare, and sometimes, even then, the color may have been changed by heat. Fig. 97 has much the same outline, but is distinctly grooved at the base. It is a fine

article, of blue flinty limestone, and is one and five eighths inches long. It comes from the same vicinity. From its general width Fig. 98 would be called an arrow-head by many, and yet its general character is that of a perforator. The worn appearance of the point tends to confirm this view, though this may have come in other ways, as in digging, for which it seems partially fitted. There are so many forms intermediate between the arrow and the drill, that it is now described with the former, in spite of a strong conviction that it belongs to the latter. It is coarsely flaked, and is two and one eighth inches long. This also is from the Seneca river.

Fig. 99 is of purplish flint, thick and smooth, and is two inches long. It is a form not so common in arrows as in spears, and this is round pointed. The rounded base is found almost everywhere, but perhaps is nowhere very common. This fine specimen is from the Seneca river, where the larger forms sometimes occur. Fig. 100 is a triangular arrow-head of common hornstone, from Onondaga lake. Its special feature is the straight and expanded base, which is also quite sharp. The length is one inch.

Fig. 101 is a broken article, but given to show a good example of what has been called here the needle point. It is very attenuated, and the section added will show how thin and delicate it is in every way. This fragment is of very thin, dark blue flint, now about two inches long, and nearly one and one quarter wide. It was found on the Seneca river, where similar specimens sometimes occur, though not very often. If found elsewhere they have not been reported, but they are so often broken that they may have escaped attention.

A large proportion of the arrow-heads figured are from Onondaga county and vicinity, partly because these were easily accessible, but partly, also, because there they are found in greater variety than in most other places, this arising from natural causes very important to primitive man. Notable forms from other parts have been figured when possible.

While it is of importance to know how widely some leading forms are distributed, and what is their comparative abundance, the study of man's early history here requires that some unusual forms should

be recorded and illustrated. These are often the links which serve to connect widely separated sites. The knowledge already gained of the primitive articles used by the Iroquois, three centuries ago, has become of great and increasing value, and will hereafter aid in solving many problems. Different nations and ages had differing fashions, and the characteristic articles used and left behind, will throw much light on the early people of New York. To collect these articles for careful comparison, to illustrate them so faithfully that distant students may have the most significant facts before them, is something worthy of the attention of a state which has already done so much in the cause of science.

SPEARS

As with arrows, so is it difficult to place an exact line between knives and spears. Indeed the primitive spear may often have been but a knife fastened to the end of a long pole, as men in more recent times have armed themselves, when lacking suitable weapons. Even arrow-heads may have been put to the same use in time of need. Spears and knives may both have been leaf-shaped, stemmed or notched, and may not differ in the least in outline. Often the thickness and sharpness are the only distinctive features. As regards size, this does not affect knives, but usually small points are called arrows, and the large ones spears.

Dr C. C. Abbott made a division of spears and lances, while L. H. Morgan, in his *League of the Iroquois*, omits spears from his description of their weapons. In his subsequent account, in the *Regents report* for 1852, he says that they did not use them, and although he simply asserted this it was not without some reason. Spears do not generally appear in early pictures, nor are they usually mentioned in accounts of early indian armor. As far as the pictures go, this is of little importance. They were sometimes, perhaps usually, drawn by European artists from descriptions given them, and they availed themselves of the privileges of art. Champlain expressly said that the Mohawk chiefs, whom he killed in 1609, wore arrow-proof armor, but in the picture they are as naked as all their followers. Capt. John Smith said of the Virginia indians, 'They of Accawmack

use staves like unto javelins, headed with bone. With these they dart fish swimming in the water.' This, however, may have been like the early Iroquois bone harpoon, barbed only on one side. The wooden sword, worn on the back, and sometimes with a deer's antler inserted, was mentioned by him, but no farther described. A strong point in regard to use is that on no Iroquois site in New York, has any early article been found which could be called a stone spear-head. At an early day they were abundant.

On the other hand, in his picture of Atotarho, David Cusick placed a spear in the hand of one of the messengers. Bruyas has allusions to spears in his early Mohawk lexicon, and their occasional use may be inferred from the *Jesuit relations*, but somewhat obscurely. The Iroquois sword, whatever that may have been, was often mentioned. Schoolcraft gives the word for spear in several Iroquois dialects, and Zeisberger uses for lance the name which appears in another lexicon, half a century earlier. One Virginia picture has indians with fishing spears, but these are described as having wooden points, not metal or stone. A weapon so useful was not likely to be abandoned until a substitute was found, but it seems certain that the large stone spear-head was not generally in use here three hundred years ago. History and archeology agree in this.

This is another of the curious proofs of a change in race and occupation. Iroquois and Algonquin alike seem to have known little of the higher stone art of their predecessors, and a weapon once everywhere abundant, had almost ceased to exist. A sweeping change had passed over the land, and the new comers did not inherit the arts of the old. If they did not, how could they have been their descendants? Allowing for every resemblance, there is still a wide gulf between the indian of our northern and eastern states, as first known to the whites, and those who preceded him. This difference can only be fully appreciated by those who have early sites of a known age, to examine.

Spear-heads vary greatly in character, and still more in size, if we make the minimum two and one half inches in length. In many places this would compel us to reckon more spears than arrows; and if we remember the vast numbers carried off — for these naturally

first attracted attention by their size — the disproportion will appear still greater. At the time of colonization and earlier, the indian's bow and arrows almost alone attracted attention. If the larger points are all spear-heads, his predecessors must have been as conspicuous for these. The difficulty might be solved by supposing the bow to have been a very recent invention in America. It is rather probable, as said before, that we have placed too low a limit on arrows, while forgetting how much of forest and river archery was at very short range.

This significant disproportion will appear in almost any good collection. In the classified list prepared by Mr A. E. Douglass, he has 261 New York spears and 963 arrows; from the country at large 2172 spears and 8396 arrows, or less than one fourth, and this would be a fair proportion elsewhere. Now in New York no spear-heads appear on Iroquoian sites, which supply many small stone arrow-heads, so that the New York proportion of early spears and arrows will be yet more equal. Supposing the bow and spear were at first used together, we would conclude that the arrow-heads should vastly exceed the spears; but under the present classification they do not. It is evident that this subject needs reconsideration.

While speaking of this it may be well to say a few words farther upon indian arms, which here included both less and more than is popularly known.

As has been said, early accounts make no direct mention of the spear, although there seem allusions to it. That used in fishing was altogether of a different kind. The bow was not the short one, so efficient in the hands of horsemen, but rivaled the long bows of England, while the arrows often exceeded the cloth yard shaft. Capt. John Smith said of the Sasquehanocks, that such great and well proportioned men were seldom seen, and that they had bows, arrows and clubs in proportion. Their arrows were five quarters of a yard in length, and in the picture of one of their chiefs, his bow reaches above his head. These were of the Iroquoian family, and in Champlain's pictures of encounters with the Iroquois proper, the long bow is everywhere seen. We may, therefore, conclude that this bow, still made by their descendants, was that commonly used in our forests in early days.

Of the making of the bow and arrow something may be said later, in connection with some peculiar curved scrapers, admirably adapted for this work, but yet too rare to have been commonly used. Capt. Smith, again, says that the Virginia indians made their bows by scraping them with shells, and the Iroquois may often have done the same, as they used shells for knives. The arrow shaft was straightened in several ways, and the Onondagas have not lost the art yet. It was headed with almost any hard and sharp material, or might be made entirely of wood. The arrow point might be fastened merely with gum, in the cleft shaft, or be bound on with sinew or thread. An Onondaga recently had a triangular stone arrow given him to affix to a shaft. He at once cleft the shaft, inserted the stone, took a piece of thin sinew, dexterously and neatly wound it about the wood and stone, and the arrow was ready for deadly use. Different nations used different arrows. Thus the Sasquehanocks had stone points, shaped like a heart, an inch broad, and an inch and a half or more long. It is probable that in this way Capt. Smith described the indented triangular arrow-head, as the Sasquehanocks were of the same family as the Iroquois. The latter used triangular arrows almost exclusively. The force exerted by these simple weapons was a matter of surprise to the colonists.

Shields were everywhere in use among the Iroquois but soon disappeared before firearms. Smith speaks highly of those of the Massawomeks, who seem to have been either the Eries, or a nation allied to them, and not the historic Iroquois, as many have supposed, although of that great family. Their light targets were 'made of little small sticks, woven betwixt strings of their hempe and silke grasse, as is our cloth, but so firmly that no arrow can possibly pierce them.' There was evidently nothing like these in Virginia, and those he had and used were everywhere recognized at once, as were their other arms. Champlain describes the armor of the Mohawks in 1609, very briefly. 'They were provided with arrow-proof armor, woven of cotton thread and wood.' Corlaer saw a sham fight among the Mohawks in 1634. 'Some of them wore armor and helmet that they make themselves of thin reeds and strings, so well that no arrow nor axe can pass through to wound them.' Similar passages might be quoted from others.

The Algonquins used shields of a rectangular form, and a Dutch writer of 1671 says that these covered the body up to the shoulders. In fighting these could be set on the ground, leaving both arms free. A Jesuit father, writing of a Canadian chief in 1633, said that he 'bore with him a very large buckler, very long and very wide; it covered all my body easily, and went from my feet up to my chest. They raise it and cover themselves entirely with it. It was made of a single piece of very light cedar. I do not know how they can smooth so large and wide a board with their knives. It was a little bent or curved in order the better to cover the body; and in order that the strokes of arrows, or of blows coming to split it, should not carry away the piece, he had sewed it above and below with a cord of skin. They do not carry these shields on the arm; they pass the cord which sustains them over the right shoulder, protecting the left side; and when they have aimed their blow they have only to draw back the right side to cover themselves.'

The use of the war club is well known, and this implement, with or without a stone axe or antler inserted, was the original tomahawk. The French writers often speak of the swords of the Iroquois and others, but without any precise description. They were sometimes fastened to poles by the Algonquins and used as spears. Stones or shells were used as knives, but the white man's knife soon supplanted these; and this was the lot of the stone axe, which was not grooved among the Iroquois, nor was it usually in New York or Canada. First, the French trade axe, and then the smaller steel tomahawk, became favorites, while guns took the place of bows and arrows.

Although spear-heads present a few varieties in New York not common here in arrows, so many are essentially the same, except in size, that they will require fewer illustrations. They are quite often of fine or showy materials, and are as variable in coarseness or delicacy of work as in other ways.

Leaf shaped spear-heads are often quite large. One of common flint, from Baldwinsville, has lost half an inch from its tip, and is still nine inches long, with an extreme width of two and three quarters inches. The base is neatly rounded, and the outline that which botanists term lanceolate. This form is common and when thin may

be termed a knife. Fig. 102 from Oswego county is a fine example of this type of spear. It is of pure white flint, and six and one half inches long. Articles of this showy material are frequent there, and are usually thin and finely worked. An early trail crossed that county from Oneida lake to Lake Ontario and the St Lawrence, and the many travelers lost some fine articles on the way. Between that trail and the Hudson river very few of the best early relics occur, as the Mohawk presented few temptations to those in search of game.

Fig. 103 has a straighter base than the last, and is not as neat in outline. It is quite thick, being eleven sixteenths of an inch in the short diameter, and five and one eighth inches long. The material is grey flint, and it comes from the east side of Skaneateles lake, in the town of Spofford. Another good example of this form is from the east end of Oneida lake, and is but three and seven eighths inches in length. A broad and fine one, with a slightly concave base, from St Lawrence county, is of white quartz, quite neatly chipped for this material. It is four inches long and one and seven eighths broad.

Fig. 104 is an example of a frequent and variable form, having a three-sided base. The edges may be straight or convex, and the thickness varies much. This comes from the north shore of Oneida lake, and is of black flint, five and five eighths inches long, and half an inch thick. These could only have been spears. A fine and larger one of common drab flint, from Baldwinsville, is six and one half inches long by two and three quarters wide. This has convex edges. Flinty limestone is a frequent material for these, and one from near Oneida lake, similar in form to the last, but little over four inches long, is made of birdseye limestone. Fig. 105 is one of the finest of these, made of common flint, and is seven inches long. It is very neat and symmetrical, and the form is the one so common in New York caches, though rarely as large as this. Large spears of this outline are not rare.

Those of a more triangular form are often knives, but spears will be found among them. It will not be necessary to figure many of these, or even to describe more than representative forms. A broad and massive one of common flint, from Onondaga lake, is five inches long, and has a width of nearly two and three quarters inches. The

base is concave, with rounded angles, and the edges gracefully curve to the sharp point. One of similar length and general outline, from the same place, is little more than half this width. Fig. 106 shows a beautiful spear or knife of fine white and somewhat translucent quartz, from Oneida lake. It is so thin and even that it might well be called a knife, but it would have served for a spear quite as well. The length is four and seven eighths inches, and it is scarcely three eighths of an inch thick. The greatest breadth would have been full two inches, had not an angle of the base been broken. Another beautiful example of dark jasper, from the shores of the same lake, is nine and three eighths inches long, and two and seven eighths wide. The base is straight, and the convex sides slightly expand toward the center. A beautiful lance-head from the Oswego river, has lost half an inch from its point, but is still seven and three quarters inches long. It is one and seven eighths inches wide at the slightly curved base, whence it tapers to the point. A similar one of grey quartz, from the same place, is five inches long, and two inches wide. The straight edges taper almost to the point, which they form by quickly curved lines. Fig. 107 is a very handsome one of white mottled quartz, three and five eighths inches long, and is also from Oswego county. The base is slightly rounded, almost immediately reaching the extreme width of one and five sixteenths inches, and thence sloping in nearly straight lines to the point.

Fig. 108 is a very remarkable specimen in every way. It is a fragment of a very large spear apparently, and is very evenly chipped. The material is a dark green jasper, and the straight and sharp base is four inches wide. The thickness is but five eighths inches. Nine inches from the base, where it is broken, it is three inches wide, and if continued on the same straight lines to a sharp point, it would have been nearly or quite three feet long. It is hardly probable that this could have been. It is remarkably flat, and possibly may have been used as an axe, the base forming the cutting edge, in that case.

Stemmed forms occur, with and without notches. Fig. 109 is quite broad, and has parallel sides, slightly notched at the expanded base. The point is quite obtuse, and the full length three and three quarters inches, with an average breadth of one and five eighths inches. The

material is a brownish drab flint, and it was found south of the Oneida river. It would have served quite as well as a knife. Fig. 110 is one of the simpler forms, with rounded stem, but ruder than in some examples, partly from its material. This is white translucent quartz, which allows little opportunity for delicate work. This form is frequent in many materials, and a beautiful one of chalcedony, with slightly rounded base, and four and one eighth inches long, comes from the town of Van Buren, south of the Seneca river. It is quite broad, with convex edges, and is slightly mottled. A much larger one, of reddish brown jasper, six and one quarter inches long, and three inches wide, has a point so broad and rounded as to suggest a spade. This is from Brewerton, and is coarsely chipped, though fine in outline.

Fig. 111 is a fine beveled spear-head of drab flint, found on the Seneca river southwest of Three River Point. It is three and seven sixteenths inches long, and about one and one eighth inches broad. This is narrow for a beveled spear-head, and of course there is a possibility of its being used as a scraper. In this example there is a notch in each lateral edge and the base is slightly wider than the blade. Simple notched forms like this are frequent in many sizes and materials, but beveled implements are much rarer. Many spear-heads occur with straight sides, but these are rarely parallel. The last four figures, all on one plate, are represented three fourths of the actual diameter.

Fig. 112 is a fine notched spear-head, with a small base. It is of common flint, six inches long, and the greatest width is nearly midway, where it reaches two inches. It comes from Baldwinsville, and, like most spears, is quite symmetrical. One much like it, but of light blue flint, was found at Cross lake. This approaches the double notched form. Fig. 113 has also a small base, and one perfectly simple. It is of a grey flinty limestone, and comes from the town of Elbridge. It is a trifle over six inches long, with an extreme width of one and three quarters inches, and is very symmetrical and neatly worked.

Fig. 114 is a beautiful notched spear or knife, made of a material much resembling moss agate, and often used in these larger imple-

ments. In flaking, this does not produce as sharp lines, nor always as symmetrical forms, but the effect is often fine. This is broader than usual with this material, and is almost three and one half inches long. It comes from the Seneca river, where articles of similar material often occur.

Fig. 115 is a very slender flint spear-head from the town of Wilna, Jefferson county. It is broadly notched near the base, and is four and one quarter inches long, with a width of much less than an inch. The base is about as broad as any part, and the slender form is not rare.

Fig. 116 is much like one already described, but has double notches on each side, although of a different character from those usually found. The base contracts to a point, and the notches are widely apart. It is a fine article of light grey flint, four and one quarter inches long, and was found in Oswego county, north of Brewerton, and half a mile from Oneida lake. The double notched spears seem more common in that vicinity than elsewhere, but this specimen is not of the usual type.

Quite massive and coarse spear-heads occur in several places, usually made of a grey quartzite, unsuitable for fine work. One of these, from Baldwinsville, is quite thick, and six inches long by two and one eighth inches broad. Fig. 117 is a good example from the same place, which is five and one half inches in length. Another from Owego, in Tioga county, is five and three quarters inches long, with an extreme width of two and three eighths inches. In this, however, the blade quickly contracts above the notch, giving the implement a much more slender appearance. Articles of this kind seem quite uniform in size. Fig. 118 much resembles these in form, especially the last described, but is much smaller, and of a variegated hornstone, a little over two and one eighth inches long, but the point is slightly broken. It comes from the Oswego river.

A broad form of the material resembling moss agate has been already given. They are usually longer and more slender. One of this description is from Baldwinsville, and is five inches long. It is a very fine example, a little unsymmetrical, rather broadly notched, and might be called a knife if it were sharper. Fig. 119 is one of the

finest of these, but has lost the extreme point, having been originally a little over five inches long. It has two notches on each side, and the surface is flatter and straighter than in others of this material, while it is also more slender. It was recently plowed up near Three River Point.

These spears and arrows with more than one notch on each side are but moderately rare, and are of wide distribution in New York, as compared with other parts of the country. Dr Rau figured a broken one from Maine, made of brown jasper, whose full length would have been six and one quarter inches. He marked this as 'quite exceptional,' and it had three notches on each side. It is of the usual New York form. Dr Abbott did not place this among his New Jersey forms, nor does it appear in Mr Fowke's chipped implements of the Mississippi basin and the southern states. The writer does not find it in his collection of outlines of rare articles in Ohio. One occurs in the collection of the Canadian institute, in Toronto, which is three and one half inches long, and has double notches, but there it is also called rare, and more have come under the writer's eye in central New York, within a radius of a dozen miles, than have been reported in all the country elsewhere. It might be considered a New York form.

A broken one of white flint comes from the Seneca river, and has two distinct broad notches on each side, with others which are obscure. This fragment is now two and three quarters inches long, with straight edges, tapering from a base one and one half inches wide. The original length would have been four and one half inches, unless it had a rounded obtuse point, as in the next. Fig. 120 is a fine article from Oswego Falls, and is of greenish white flint, four and three eighths inches long. The double notches are much more distinct than in the fragment just described. One of white flint comes from the Mohawk valley, and is five inches long, with three notches on each side. Another, made of red jasper, is from Brewerton, and is three inches long, with double notches. Similar ones occur there. A well wrought one of drab flint, from the same place, is three and one half inches long, and has double notches. A smaller and broadly triangular specimen, of common flint, comes from Skaneateles lake.

It has double notches, and is two and seven eighths inches long. Fig. 134 was inadvertently placed out of its proper order, but is in every way the finest of these yet found. The material is clouded quartz, and thus the flaking produced no conspicuous lines on the surface, but the outline is very neatly wrought. It is six and one half inches long, and was found in removing a stump three quarters of a mile north of Brewerton, in 1896. It is flat and thin, and nearly two inches wide, but its prominent feature is the number of notches, five on one edge and six on the other. The base is truncate, and the edges slightly curving to the sharp point.

Fig. 121 is a good example of a thin and narrowly notched spear-head of common hornstone, quite sharp, and attenuated at the point. It is about two and five eighths inches long, and is a very frequent form. This specimen is from the Seneca river, as is the next. Fig. 122 is also of hornstone, but quite thick, and slightly shouldered. The base is long, and does not expand, but is rounded at the end. It is three and one eighth inches from extreme base to the point, and is typical of a large class, very widely distributed.

Fig. 123 is a notable spear-head from Owego, near the Susquehanna river. It is of a blue grey flint, seven and one quarter inches long, and is a very rare if not unique form. Either end might have been used for a spear, had occasion required, but apparently this was the office of the longer and slender part. This had mostly concave edges, rounding to the point. The shorter and broader portion has convex edges throughout. The whole implement is neatly wrought throughout.

Some stemmed spear-heads have concave bases; perhaps no great distinction, and yet one which has attracted attention. Many others, slender, but of the notched arrow form, are made of white flint, a favorite material for spears, but obviously brought a long distance. While fine examples they present few peculiar features. Stemmed spear-heads with a convex expanding base are also frequent, and are usually notched. Fig. 125 shows a parallel sided form from Skaneateles. It is of drab flint, two and seven eighths inches long, and one and one eighth inches wide. While it is notched, the general outline is a long pentagon. Much like this, but larger, is one from Queens-

bury. Judging from collectors' reports, fine spears may not be frequent in that part of New York. In the former Wagman collection, made at Saratoga and near Lake George, but 36 spear-heads were catalogued. The largest was six and one half by two inches, and another, six by one and one half inches, had serrate edges. This collection was sold and dispersed in 1886. In Holden's *History of the town of Queensbury,* however, we are told that arrows, spears, and other indian relics are found at every carrying place between Albany and Montreal, and this we might have expected. Mr Holden adds that while gun flints, bullets, stone arrows and spears were spread broadcast in Queensbury, there were particular places where they were found abundantly.

Out of the many examples of spear-heads but one more will be noted now. Fig. 124 is a broad and thin chalcedony implement from Baldwinsville. It is triangular, with an indented base and convex edges. The length is four and one eighth inches, and it is a little over two inches wide. One peculiarity of this fine article is the neat and small notches, which are almost circular.

KNIVES

The ruder forms of knives require but slight attention, as almost any flake or piece of hornstone might serve a temporary purpose, whether large or small. Early accounts show us an extensive use of bivalve shells, with or without alteration. Few of these can be found now, but the rude stone knives are abundant in many places, and are interesting as showing, not so much progress in economic arts, as the frequent utilizing of otherwise waste material. A flint chip was neatly edged on one side, or more, and did all that was required without farther elaboration. Fig. 126 is the type of many rather large and straight pieces, triangular in section, which were often used as knives, and might have served for scrapers. One angle or edge is left without farther work, but one or both of the other two may be delicately chipped for more effective use. Of course these could have been employed only in very simple ways. This one is of grey flint, and comes from Seneca river, where the form is frequent on many camp sites. The length of this specimen is three and one quarter inches, and one angle is quite obtuse.

Many rude knives, large and small, were nearly circular, and these also will require but slight notice. They are chipped to a sharp edge all around, and may sometimes have served as scrapers, although they do not have their peculiar features. The leaf shape is also very common and of wide distribution, varying from very small to very large. A very long one of brown flinty limestone, seven inches in length, has a surface greatly curved, being convex on one side, and concave on the other. The concave surface is a large single flake, except for the chipping along the edge. This special form is not rare, and is almost as much scraper as knife. The one described is two and one half inches wide. Another of dark hornstone, from Oswego Falls, is a typical leaf-shaped knife, five and one half inches long by two inches broad.

Fig. 127 is interesting, as being one of 23 found in the mound at Greene, Chenango county. It is of yellow jasper, three and three quarters inches long and two inches wide, and may have been buried there long after the mound was made. In the *Annals of Binghamton,* it is stated that 'At one point in the mound a large number, perhaps two hundred arrow-heads, were discovered, collected in a heap. They were of the usual form, and of yellow or black flint. Another pile of 60 or more, was found in another place in the same mound. A smaller leaf-shaped knife of yellow jasper, two and three quarters inches long, also came from a grave in Greene, as reported, but may also have been from this mound, so many articles of yellow jasper having been taken from it.

A very large and rude knife, seven and one quarter inches long, also came from a cache of 19 pieces at Baldwinsville. It was an unusually rough and mixed lot, nearly all of yellowish jasper, tinged with brown. Most of the pieces had the form usual in caches, but some were of ruder outlines, and a few could only have been utilized as scrapers.

Knives which are elliptical, or of a long diamond form, pointed at both ends, are often very fine, and are by no means rare. Fig. 128 is of drab flint, four inches long, and more slender and pointed than many of this form, besides being more angular in the center. It is quite neatly worked. A fine one of yellow jasper, from the Oneida

river, is almost a true ellipse, five inches long by two and three eighths inches broad. It is scarcely pointed, and many have this feature in other forms. A small one of common flint, which is but two inches long, differs little from fig. 128 except in size. Fig. 129 is a beautiful knife of light blue flint, five inches long. It is not a rare form, but with this outline is quite as often a scraper as a knife. Nothing can be prettier than fig. 130 which is of a beautiful banded white flint, three inches long. It comes from the town of Van Buren, some miles south of the Seneca river. Among the finest of this form is a very long and slender one from Chautauqua county. It is 11½ inches long, two and three quarters inches wide, and about a quarter of an inch thick near the two sharp points. The edges present so symmetrical a curve that the outline may be reproduced from these measurements. It was a surface find.

Three small elliptical flint knives are represented by the following numbers, all from Seneca river. These are commonly less than two inches long, but may reach seven inches. Fig. 131 is one of the small specimens, made of common flint. It is one and five eighths inches long. Fig. 132 is of similar outline, but made of dark blue flint, and of the same length. It is a neater article. Fig. 133, of grey limestone, is more slender, and is pointed. The point and part of the edges are slightly ground. It is two inches long. Specimens like these were once quite frequent.

Many stone knives approach what we call a knife form, and vary much in size. One of brown flint, four and three eighths inches long, is but moderately curved in its outline, while others are conspicuously so. A black flint knife, three and one half inches long, found on the Oswego river, is very distinctly curved in this way. Fig. 135 is of this curved form, and is quite thin and sharp. It seems to have had a straighter part of some length, for insertion in a handle. This has been partly broken off, but the remainder of the implement is still three and one quarter inches long. It is of brown flint, and comes from the Seneca river. Evans described some curved knives in Great Britain, much like these, and thought them peculiar to that land, but could assign no use for them. They seem well adapted for several purposes, but their very form suggests the knife, alike available in war or hunting.

Fig. 136 is somewhat like the last, and from the same river. It is much thicker, and not unlike some of the curious scrapers yet to be described. It is of brown flint, three and one quarter inches long, and somewhat twisted. Several have this feature. Fig. 137 is curiously curved, but is typical of quite a group. It is of brownish flint, three and five eighths inches long, and comes from the east side of Skaneateles lake. The general thickness is considerable, but the back of what might be called the handle is not sharpened, as is the rest of the implement. Another curved and twisted knife of common flint is six and one quarter inches long. All of this type vary much in thickness and neatness of work. Fig. 138 may be classed with these, though with quite a different outline. One edge is nearly straight, and the other much curved, the surface is also much curved, being concave on one side, and rounded on the other. It is of brownish flint, two and one half inches long, and comes from the Oswego river.

Some of the most delicate knives have straight bases and curving sides, the blade being broadest toward the point. Fig. 139 is one of these, of brown flint, delicately worked, and three inches long. This is from the Oswego river, and is typical of many others, always neatly finished, but often broken. Another from Three River Point is of yellow jasper, four and one eighth inches long. This is also a fine example. A longer and neatly worked specimen, made of brown flint, and five inches long, is from the east end of Oneida lake. Evans called a similar form in Great Britain a dagger, and it readily suggests that weapon, though usually rather frail for any rough usage.

Another frequent form of knife in some places is thin, parallel sided, and broken squarely off at each end, as though by design. They are somewhat local, and on many sites are never found. Fig. 141 represents one of these, of common flint, thin and bent, and two and three quarters inches long. This is from the Seneca river, where almost all have been found on two or three sites. One from Queensbury, three and one quarter inches long, seems much like these.

Triangular forms, with straight or convex sides, are common, and hardly require illustration. They vary much in width and thickness, and reach five inches in length, but are usually less. They are often curved on the surface, and are sometimes quite broad. Fig. 142 is

one out of a number of narrow knives of this form, all found on one small site on the Seneca river. They varied from three to four and one half inches in length, and were very thin and sharp. From their numbers and uniform character, it is probable they were scattered from a cache. The one figured is four and one half inches long, and one and one eighth inches broad. One of the finest of this form is of striped jasper, five inches long, and comes from Oneida lake. This, however, has curving edges, and is broadest near the center. A broader form than that last figured, appeared in a lot of 125 like specimens in a grave in Bellona, near Seneca lake. A few are nearly long, straight sided triangles. Some knives have the simple pentagonal form, so common in caches, and these are sometimes bent. This peculiarity is frequent in notched forms, usually classed as knives because of this. Fig. 146 shows an arrow form thus bent. In one instance a broad notched form from Oswego Falls, three inches long, has a distinct double curve of the surface. Other notched forms, and some of the simpler, may not have an equilateral blade.

Fig. 143 is a fine knife of grey limestone from Cross lake, much like the Queensbury knife just mentioned. It is truncate at each end, three and five eighths inches long, one and one quarter inches broad in the middle, where it is widest, and is somewhat thick. Fig. 140 is a small, slender knife, approaching the drill form, if not an implement of that kind. It is of variegated flint, two inches long, and comes from Seneca river. Fig. 144 is a coarse and heavy curved knife of hornstone, from Onondaga lake. It is five inches long and two and one quarter broad, with nearly parallel edges. This is quite a frequent form. Fig. 145 is the ordinary leaf-shaped knife found almost everywhere. This is of common flint, three and one half inches long. In other examples it would vary in size, length or breadth, ranging from broad to narrow, and similar differences will be observed in every form here represented.

SPADES OR HOES

Spades are of very uncertain character, and some articles possibly used as such might be considered spears, knives, or even rude celts. Few are found that we can call spades and nothing more. The early

visitors had little use for those of stone here, as they came for hunting and fishing, and not to till the soil. The Iroquois, who were an agricultural people, used stone as little as possible, and made their hoes and digging tools of wood or bone; mostly the former. In Bruyas' *Mohawk lexicon,* about two centuries old, onarate is the wooden hoe, but there is no word for spade, which they would only use in digging post-holes, or pits for caches, where the hoe would be quite as serviceable. In the early book called *New England prospect,* it is said that part of the women's work was 'their planting of corne, wherein they exceede our English husband-men, keeping it so clear with their clamme shell-hooes, as if it were a garden rather than a corne-field.' Loskiel said of the cultivation of corn 'They used formerly the shoulder blade of a deer, or a tortoise-shell, sharpened upon a stone, and fastened to a thick stick, instead of a hoe.' In Van der Donck's *New Netherlands* are interesting notes on points connected with indian agriculture, although their implements are not described. 'They say that their corn and beans were received from the southern indians, who received their seed from a people who resided still further south, which may well be true. . . The maize may have been among the indians in the warm climate long ago; however, our indians say that they did eat roots and the bark of trees instead of bread, before the introduction of indian corn, or maize.' They had beans before the whites came, and 'have a peculiar way of planting them, which our people have learned to practise: when the Turkish wheat, or as it is called, maize, is half a foot above the ground, they plant the beans around it, and let them grow together. The coarse stalk serves as a bean prop, and the beans run upon it.' The Onondagas have a pretty story about this.

In the fall they burned over the places which they wished to plant the next spring. There are many accounts of the large caches in which they kept their corn, and these are yet found in many places, while the corn itself is often plowed up. One piece of woodland in Montgomery county is full of the open pits, but the Iroquois also stored corn in boxes made of bark, and sometimes had vast amounts of this. The cache method, however, was very common, and in the pits both corn and beans were stored. In his early account of the

Mohawks, the Rev. Johannes Megapolensis says, 'When their corn is ripe, they take off the ears and put them in deep pits, and preserve them therein the whole winter.' A fuller account will be found in the *New England prospect.* 'Their corn being ripe, they gather it, and drying it hard in the sunne, conveigh it to their barnes, which be great holes digged in the ground in forme of a brasse pot, seeled with rinds of trees, wherein they put their corne.'

The origin of indian corn is a question of much interest, and a great deal has been written upon it. Besides what has been said above, Roger Williams gave the New England tradition: 'The crow brought them at first an indian grain of corne in one eare, and an indian or French beane in another, from the great god Kautántouwit's field in the southwest, from whence they hold came all their corne and beanes.' Corn hills were large, and stood well apart. They are still to be seen in some New York woods, and the cultivation was very simple. Roger Williams has a note on what he thought a curious preference in tools: 'The indian women, to this day, (notwithstanding our howes,) doe use their naturall howes of shells and wood.' Spades are not mentioned, and, bearing this fact in mind, it is quite likely that those stone implements of New York which resemble what are called spades elsewhere, are to be considered hoes, if they were really digging tools. The question admits of reasonable doubt, but the classification may be allowed for present convenience. It may be added that less was needful for digging than is often supposed. In an emergency the writer has been surprised to see how much excavating he could do on an indian site with a sharp stick, or a broad and pointed stone. With improvised tools and plenty of muscle a great deal could be easily accomplished, but the necessity for this was so rare in indian life that little faith need be placed in the New York stone spade.

Fig. 147 represents the finest of these articles known to the writer. It is a leaf-shaped implement of a bluish grey stone, and came from Oneida lake, where it was plowed up in 1877. The average thickness is three eighths of an inch, and the length is 11¼ inches, with a breadth of five and one quarter inches. This and the two following figures are reduced to about two thirds of the actual size. It is sharpest at the broad end. This article seems much too large for either spear or

knife, though both these have been found quite as long, and it may be best to consider it a digging implement for the present. Smaller specimens are common, with a similar outline. An elliptical one of drab flint, five and three quarters inches long, also came from Oneida lake. Another, with straighter sides, is from Brewerton, at the foot of the same sheet of water. This is of grey flint, and is seven and three eighths inches long, and three and one half inches wide. This would be called a knife but for its size. It is not equilateral, but while one of the lateral edges is straight, the other is longer, and curves gradually to meet it at the point. Quite a number are between five and six inches long, coming from several places.

Two fine leaf-shaped implements from the Susquehanna river should be mentioned. One is from Nichols, and measures 10½ by six inches. It was found 25 years ago. The other is from Owego, and is a little smaller, being 10 inches long by four and three eighths wide. It is of a light translucent flint, and was found 50 years ago, just below the Susquehanna river bridge.

A different form of flint implement was certainly used for digging, although in a very moderate way. The form was often that of a shouldered spear, but with the point rounded and polished by contact with the earth. Fig. 149 is a good example from the Seneca river, made of grey flint, and four inches long. Fig. 148 is another of common flint, found near Rome, N. Y. This has no shoulder, and may also have been used as a knife, but the narrow point is highly polished by use. It is three and one quarter inches long. It is quite probable that this was a secondary use; a broken point being re-chipped, and then used in this way. It is even more likely that spears and knives were sometimes used in digging.

Fig. 150 is a pointed leaf-shaped implement, which one hesitates to call either spade or hoe, so handsome is the material and so fine the work. It is a fine orange jasper, five inches long and nearly three and one half inches wide. It was found on Onondaga lake, where others of less beauty occur. This figure and the following two are reduced to three fourths of the actual size. Others, of the same general shape as the last, are less pointed.

Some broad, thin, and celt-like chipped sandstones are often now classed as spades, and occur on some village sites. They would do

moderately well in digging, though a sensible savage might have much preferred a sharp stick, horn, or bone. As hoes they would have been more useful, and this may have been their office. They range from four to seven inches in length, with a proportionate width of more than half, and have a wide distribution. Fig. 151 will suffice as an example of these. It is of red sandstone, having parallel edges and rounded angles. It is chipped much like the flat net sinkers, but has no notches. The length is five and seven eighths inches, width three and three eighths, and thickness five eighths of an inch. This is from a village site on the Seneca river, where many were found. On some smaller sites they also occur, while on others they are altogether lacking. It may be added that the nature of these sites does not favor the theory that they were used in agriculture.

CHIPPED STONE AXES

Grooved axes are rare in New York and Canada, and probably were never used by the Huron-Iroquois family. Chipped implements of an axe-like form are no more plentiful in New York, while the common celt, or polished stone axe, without grooves, is both abundant and variable. These were used by the Iroquois, even after white contact. Although iron axes quickly came into use, yet Champlain said that the Mohawks were not well supplied with these in 1609, and some still employed the primitive axe of stone. Fig. 152 shows a rudely notched implement of brown sandstone, from Oswego Falls, much like a modern hatchet in outline. It is five and five eighths inches long, and is quite flat. This is an unusual form, although other rude implements have some resemblance to it. A much neater and more regularly chipped axe of the same material, is from Brewerton. It is five inches long, with a width of two and seven eighths inches towards the cutting edge, and one and one half inches at the top. The lateral edges are straight. Fig. 153 represents a fine article of ferruginous flint, somewhat square, and five and one eighth inches long by about three and three quarters wide. It comes from the Oneida river, and is of moderate thickness. There can be no doubt that it was used as an axe.

Chipped celts were quite abundant almost everywhere, and were sometimes a final, sometimes a transitional form. The usual course

was to chip the stone into the shape of the celt, when this could be done. This might go no farther, for as a weapon of war it was already serviceable, and perhaps in some of the arts of peace. If the material was fine, it might afterwards be picked and polished. Often the edge was ground before these things were done. The finish has nothing to do with the age, for the rudest and most finished forms may be found, side by side, on the same village site. Many show all three processes in the unfinished implement. The work might go on for years, at intervals, the weapon being used nearly all the time. As the difference is thus only one of finish, except in flint celts, no illustrations need be given of those of common stone.

A micaceous stone is frequent on a few sites, showing no signs of work, but presenting such resemblances to finished celts that one can hardly doubt its use. It would soon lose all marks of human skill.

In the examination of Iroquois sites, one can hardly fail to observe how the stone age was on the wane, in this family at least. With rare exceptions stone implements were rude, and there was neither the variety nor beauty in articles of stone everywhere seen among their New York predecessors. Bird amulets, gorgets, stone tubes, scrapers, drills, and banner-stones were already things of the past. Arrows were small, comparatively few, and mostly of one form. Stones were still used in grinding corn and cracking nuts, but the wooden pestle and mortar had their established place among prosperous people. Stone vessels were forgotten, and bone and horn took the place of flint. Still, stone was necessary, and the ungrooved axe was often finely finished.

There are a few chipped celts of flint, often ground at the edge, but ground flint is rare in this country. Fig. 154 is a good example, coming from Onondaga lake. It is of common hornstone, two and three quarters inches long, seven eighths wide, and five eighths of an inch thick. It is ground to a moderately sharp edge at both ends. A broad edged one of chalcedony, three and five eighths inches long, comes from Oswego Falls. Fig. 155 is of grey flint, two inches long, one inch wide, and nine sixteenths thick. The cutting edge is neatly chipped, and one surface is much flatter than the other. This is from Onondaga lake. A much larger one of grey flint, comes from the

town of Marcy. This is eight and three eighths inches long. Fig. 156 is a well marked form. In this most of the surface is flat, the cutting edge being sharply beveled on each side. It is of drab flint, two and one quarter inches long, and five eighths of an inch thick. It comes from Seneca river. Another finely chipped celt is from near Skaneateles lake, and is represented by fig. 159. It is of brown flint, over an inch thick, and sharpened at both ends. The length is nearly four inches, and it is symmetrical throughout. Fig. 160 is of common hornstone, with parallel sides and rounded edge. It is from Cross lake, and is two and one half inches long, one and one eighth wide, and three quarters of an inch thick. It is very neatly chipped. Fig. 161 is of unusual material, being of clouded quartz, well worked. It is two inches wide, and two and seven eighths long. This is from Onondaga lake. Others might be described, but there is no great variation in form. Only a few are elliptic, but several have the wide and ground edge. Although rare, they are widely distributed, and are sometimes of choice material.

An earthwork in the town of Granby has no relics beyond small fragments of earthenware, a few flint flakes, a flat sinker, and one or two skeletons, but a rude celt of greenstone, seven and one quarter inches long, was found quite near. The indications are that its occupation was very brief. An earthwork, three miles southeast of Baldwinsville, has fine celts, but many more which are very rude, varying from three and one half to nine inches in length. One of the latter length is massive, prominently ridged on one side, and but little worked. Another of talc, four inches long, and laterally curved, is rudely chipped, but is remarkable for form and material. Some of these rough celts are a broad ellipse. The only earthwork in Wayne county furnished a rude one of dark crystalline stone, nine and one eighth inches long. Numberless examples might be given.

PERFORATORS

Among the most remarkable and perplexing articles of flint are those known as perforators or drills. They are widely distributed, and are of a comparatively early date, in New York at least, not having been used by the Iroquois, who preferred awls of horn or

bone. Some are found in Great Britain, but of simple forms and rude workmanship. Dr Abbott well said of these, and some other things, 'It is certain that the majority of our specimens, such as scrapers, drilling stones, etc., are manufactured with greater elegance, and evince a more thorough knowledge of the chipping art. The English specimens appear to be all flakes, which have had the edges chipped, that the required shape might be given to the specimen.' Ours are usually worked over the entire surface, but not invariably, for we have specimens as rude as any in England.

In some places perforators are rare, and but six were catalogued in the Wagman collection at Saratoga. Out of 327 in Mr Douglass' collection, but 29 are credited to New York, where they really are abundant.

So slight is the division between these and arrow-heads, in very many cases, that it has recently been suggested that they are but a slender form of these. Sometimes it is a question to which class to assign some forms. A series of triangular arrows from one site, commencing with a broad form, grades insensibly into those so slender that they would be called drills anywhere else. The main difficulty, however, is to assign them a distinct use. They fit well in the spiral perforations of gorgets, but no great length would have been required for these. Possibly they may have been used in perforating wood, but this is doubtful. For piercing leather a sharp bone or thorn would have been preferable. An early writer, in speaking of shell beads, said they were drilled with a nail or a sharp stone. We might suppose that their use was of this nature, were it not for their abundance in places where large shell beads were not likely to be made. Their fragile character and few signs of use, increase the difficulties of the problem. Some, therefore, have suggested that many were pins, more or less ornamental. Dr Rau thought some of the straight, double pointed forms might have been used in fishing, the line being attached in the center, according to a well known method. The question can not be satisfactorily discussed now.

Long straight perforators or drills, for the common name will be used here, are quite common, and are usually of grey, drab, or black flint, often expanding at the base. They suggest awls or bodkins, at

once. Fig. 157 is such an article, of common flint, representing a frequent form on the Seneca river. It is three inches long, and the base is but slightly wider than the main part. One of the same form and material but four inches long, comes from Onondaga Valley. This also is straight, and has but a trifling expansion at the end. Another of similar form and material, from Brewerton, is a little thicker, and three and five eighths inches long; nor are these solitary examples, although they may represent the extreme length of this form here.

Some expanded forms do not exceed an inch in length. Fig. 158 shows one of these which is not an inch long, but which is neatly worked and symmetrical. It is of bluish flint, and was found at Baldwinsville in 1878. Fig. 162 has a thicker base than usual, and indeed is somewhate massive throughout. It is of brown flint, three and three quarters inches long, and comes from the Oswego river. Fig. 163 is a beautiful drill, yellow at the base and shading into red, which is the color most of the way towards the point. This may have been caused by heat. The base is moderately broad with concave sides, and is three and three quarters inches long. It comes from Onondaga lake. In many such forms there is little more than a quick expansion of the base, tapering, rounded, or angular, as the case may be. These vary little in length, but are often quite wide. Fig. 164 unites the scraper and drill, as in some other cases, having a scraper edge almost to the point. It is of mottled flint, two and one half inches long, and was found on the Seneca river.

Another form of the long drills was distinctly notched. Fig. 165 is a beautiful example of these. It is from the same river, and is of a mottled grey flint, three and seven eighths inches long. Both work and material are fine, and it is slightly barbed on one side. Very closely resembling this is another from the Mohawk, at Canajoharie flats. It is of drab flint, a little shorter and wider than the last, but equally fine. The length is three and three eighths inches. A broader form still, but of about half the length, comes from Brewerton, and there are many approaching these.

Excepting as they approach the triangular form, those with a very long and broad base rarely reach two inches in length. Fig. 166 is

very odd, the broad and notched base having elevated points on either side. It is from the Seneca river, and is of light brown flint, one and three eighths inches long. Fig. 167 is a frequent form, with a broad and deep base, which in some may be widest above or below. Sometimes the contraction above the base is very moderate at first. This is of common flint, and is one and one quarter inches in length. It is one of the frequent forms. Fig. 168 is one of the largest and oddest of this variety, and comes from Brewerton. It is of brown flint, and the broad and curving base has obtuse raised points, strongly suggestive of those in a drill already figured. The length is two inches, and it is nearly as broad.

Some of these expanding bases suggest the gimlet and thumb-screw, and might have been used with or without an additional handle, but the straight and slender ones, if used for perforating, would have required a handle of some kind. Fig. 169 is a small example of the thumb-screw pattern, the three arms being much alike, though one is a little longer and narrower than the others. It is of drab flint, one and one eighth inches long, and could be easily turned by the fingers. This is from Seneca river, and another from Brewerton, two inches long, presents the same concave base. This is carried still farther in fig. 170, a specimen unfortunately broken, where the wide base is almost as slender as the shaft. One prong terminates in a notched and rounded point, as if for suspension, and it is a question whether the broken part had the same feature, as is probable, or whether it was a double pointed drill. It is of black flint, two and one half inches long, and comes from the Seneca river. A smaller one, somewhat like this but with a narrower base, was found on the Canajoharie flats. The one figured, however, is unique in some respects.

Fig. 171 is a good example of the gimlet form from Onondaga lake. It is of grey flint, two and one half inches long, and very symmetrical. One from Geneva is almost equally so, and is two inches in length. This form is rarely perfect, from its great liability to injury, but more might be described. Among those having deeper expanded bases is one of rosy quartz, one and three quarters inches long. This is also from Geneva, where many small forms have been found. There are

one sided basal drills, and those oddly curved, but these seem mere freaks, and but one will now be mentioned, because some have thought it may have been used in forming a primitive fish-hook, by binding it to a perforated stick. Dr Rau (see *Prehistoric fishing*, fig. 180) shows one closely resembling this in a Greenland hook of wood and stone. Capt. John Smith speaks of a similar use of bone in Virginia. 'Their hookes are either a bone grated, as they noch their arrowes in the forme of a crooked pinne or fish-nooke, or of the splinter of a bone tyed to the clift of a little sticke, and with the end of the line they tie on the bait.' That this article is well adapted for such use will be readily seen, and Dr Rau's figure seems almost conclusive proof.

Occasionally a drill is widened in the middle, between the base and point. Very simple examples of these occur, but sometimes they are rather curious. Fig. 173 is a flat form of drab flint, one and one half inches long, and might be described as a double thumb-screw. While the center has been well preserved, both points have been broken off, but they were evidently quite short when perfect, so that the figure presents very nearly the original outline. Even now it is a most interesting article. Fig. 174 is another odd form, very wide, and deeply notched. Above the notches it might be described as broadly winged, but the barbs form its most distinctive feature. It is of drab flint, one and one quarter inches long, and was found not far from Rome, N. Y.

Many drills are nearly triangular, and occasionally one may have been formed from an arrow-head. Fig. 175 may have had such a primary use, followed by a moderate narrowing of the point. It is notched, of dark flint, one and seven eighths inches long, and was found near Three River Point. Fig. 176 is a straight perforator of common hornstone, two and five eighths inches length. The base is better finished than in most examples of this variety, which are often smaller, and of black flint. This comes from Onondaga lake, where many of this form have been found.

Sometimes one occurs, straight and uniform, which has a rounded point at each end. These grade into a broader form, which seems a small knife. A few have an erratic form, marked by a one sided

base. Some convex sided arrow-heads, as has been said, are drawn out into a slender point, suggesting a perforator, and there are rude specimens, perhaps used for temporary purposes. One of these forms, not rare, is a slender splinter of hornstone, triangular in section, and chipped so as to present three faces on the shaft. In such cases the base is sometimes left unaltered.

While perforators are widely distributed, from the Atlantic to the Pacific, their most ornamental development seems to have been in Missouri, where they grade into animal forms. This gives countenance to the idea that some may have been used merely as ornaments, a remark which will not apply to all.

SCRAPERS

The typical scraper has one flattened side, usually formed by one or two broad flakings; and another, more or less elevated or ridged, which is beveled down to the other surface. It is often combined with the knife or drill, especially in implements approaching the leaf shape, or in distinctly curved knives. Scrapers are often very rude, some being made of flat pieces of hornstone, merely chipped down to a scraper edge. Sometimes other flat siliceous stones were utilized in the same way, resulting in rude and unusually large implements of this kind. Many were made of broken arrows, in which case the under surface may be quite delicately chipped. This secondary use may be the reason why they were so long overlooked here, as they were not attractive articles to collect until their true nature was known.

Many of them may have been used in handles, as in comparatively recent times elsewhere, but others were so large as not to require these. Carved handles of horn or bone have been occasionally found, but these may have belonged to other implements, as they came from Iroquoian sites, and that great family knew little of stone scrapers or perforators. Absence of such handles in other places, however, proves nothing, as horn or bone articles quickly decayed except in fireplaces and refuse heaps. It is still more likely, in a forest land, that handles would have been made of wood. Small scrapers would often require handles of some kind, but the larger ones might not.

They vary greatly in form and finish, and some very closely resemble those yet used by the Eskimo. They form a very widely spread class of implements, often adapted to local needs.

The ruder scrapers need not be illustrated now, as they took almost any form, like the ruder knives, presenting nothing characteristic except the beveled edge and flat under surface. A chance flake, or a flat pebble might be otherwise unaltered. Some are extremely small, being less than half an inch long, while others are quite massive. Fig. 178 is a fine example of a simple and large form from the Seneca river. The material is brown flint, two and five eighths inches long. This is boldly but neatly flaked, and is more massive and uniform in thickness than usual, as well as flatter on the under side. Another from Onondaga lake, of mottled flint and one and seven eighths inches long, is very much like this, but the under surface is somewhat curved and twisted, and the implement is proportionally broader. One of yellow jasper, from Oswego Falls, closely resembles this in size and character. A fragment of a large one from the Seneca river, is still two and three quarters by three and one quarter inches, but is of a ruder type. A very neat and depressed scraper, almost of a horseshoe form, was found in the town of Marcy, north of the Mohawk river. It is of drab flint, and is three and one quarter inches in length.

Fig. 183 is given on account of its small size, although typical of quite a class. There is a small site on the bank of the inlet of Onondaga lake, which was a frequent camping place in early days, sometimes apparently occupied for months at a time. Bone harpoons, pottery, flint and bone articles, the so-called spades, and other things occur there. In excavating an ash-bed there this little scraper was found. It is of common flint, ridged in the center, and but seven sixteenths of an inch long. Another, but five eighths of an inch in length, comes from Seneca county.

Fig. 177 is a very curious article, not a typical scraper, and yet probably used for one of its purposes, that of fashioning the shafts of arrows. It seems to have been made from a broken arrow-head, and was found in 1889 in a cache in Cayuga county. The cache contained also twenty arrows and the same number of flint knives, a quantity of mica, some antler prongs, paint, and other things. Also a turtle

totem of grey stone. One of the arrows was translucent, and another was of white quartz. The remainder of the arrows and all the knives were of native hornstone. The writer has seen a similar article from Missouri, and supposes it to have been used in scraping the shafts of arrows in the speediest way.

Fig. 179 has one end rounded, and the other straight. The edges are somewhat parallel, but the surface is widest along the center. These opposite edges are beveled from opposite surfaces, so that there are one or two scraping edges, whichever way it may be turned. It is probable that some of the beveled arrows, so called, were scrapers of this kind. Part of the length has been lost, so that no scraper now appears at that end, if indeed there was ever any there, for in that part the edges become sharp, and probably the knife and scraper were combined. It comes from the Seneca river, and is made of brown flint, still two and seven eighths inches long. A smaller one of these has much the same character; the base and edge being beveled on one side, with the other edge beveled from the other surface. It is of light drab flint, one and three quarters inches long, and does not have the knife edge of the last mentioned. This was from Three River Point. Another similar scraper, of light grey flint, has four beveled edges on one side, nearly parallel, and is one and three quarters inches long.

Some which have been called gambling flints, are small and nearly square. They are not all distinctly scrapers, and seem to have been Iroquois gun flints, made by themselves for an emergency. The beveling is from both sides, as in a knife. As some of these were certainly made at a time when the Iroquois used deer buttons and peach stones for gambling, and as most of them were associated with European articles, they may well be classed as indian gun flints. Fig. 180 is one of these from the Seneca river. It is of dark flint, nearly an inch square. The square center is flat, and the stone is beveled to the edge on each side. Fig. 181 shows a Cayuga specimen, to which the name of gambling flint has been distinctly given. It is of hornstone, and was found, with 20 others, in a grave well supplied with European articles. This is an inch across, but others were smaller. A gun, bullets, and two gun flints, were among the

articles accompanying these. Fig. 182 is a smaller one from the same grave.

It will be remembered that the proper name of the Mohawks was Kaniengas, People of the flint, and that their proper symbol was a steel and flint; often only the former. Their associations were not so much with the flint as material for arrows. From almost the first they connected with it its fire producing powers. As soon as they had guns — and they were the earliest New York indians to possess them — they saw occasional economy in the use of their favorite stone. On this point there is a curious passage in the *Jesuit relations* of 1668, of an incident which happened when the French missionaries were about two miles north of Ticonderoga. 'We all stopped in this place, without knowing the cause of it, until we saw our savages gathering upon the edge of the water, gun flints, all nearly shaped. We gave this not much thought at the time, but afterwards learned the mystery, for our Iroquois told us that they never fail to stop in this place, to render homage to a nation of invisible men, who dwell there in the depth of the water, and are occupied in preparing gun flints, nearly all ready for the passers by, provided they do their devoirs in presenting them tobacco; if they give much of it they make them a large largess of these stones.' These men were farther described, but the French concluded that, in storms, 'when the wind comes across the lake, it casts upon this shore a quantity of stones, hard and fit to strike fire.' This sufficiently shows that the Iroquois often provided their own gun flints, instead of using those imported by traders.

Many scrapers are almost or quite elliptical, and some circular forms may be gun flints. Fig. 184 is a fine example of the former class from Brewerton. It is of drab flint, thin and flat, and the edges are beveled all around from one surface. It is one and three eighths inches in length. One much like this is from Auburn, and is one and five eighths inches long. It is by no means a rare form, but grades into knives.

A heavy, rounded, triangular scraper from Oswego Falls, has a double curve in the long section, and is one and one half inches long. Another of similar outline is from Cross lake. It is, however, uniform in thickness, with edges abruptly beveled in opposite directions,

forming a double scraper, which is not a rare feature. The length is but one inch. A handsome one of brownish, banded flint, one and one eighth inches long, comes from Baldwinsville. Fig. 185 represents this. It is of uniform thickness, a quarter of an inch, but is peculiar in having a concave and convex surface, with the scraper edge beveled from the former to the latter.

Fig. 186 is a long, leaf-shaped scraper or knife of brown flint, found near the rifts south of Three River Point. It is five and one half inches long, and suggests a long knife, but has but one or two long flakings on the under surface, to meet which there is the usual bevel nearly all around. It is moderately thin, and very much twisted. Several of this form and size occur, with many variations, and nearly all would serve for knives almost as well as scrapers, although having the characteristics of the latter.

Fig. 187 shows one of the finest scrapers, in material and form almost identical with some knives, except in the edge. It is of lustrous brownish grey flint, four and one eighth inches long, and widest in the middle, whence it tapers almost to a point at either end. This was found at Onondaga lake. The greatest width is one inch, and it is less than half that in thickness.

Quartz scrapers are rare in New York. One from Brewerton, one and three eighths inches in length, is triangular, and like others with that outline, is much the thickest at the broad scraper end. Fine leaf or rather often triangular forms, however, occur in common or light grey flints. Fig. 188 is one of these from the Seneca river, which is of dark blue flint, two inches long, and very evenly beveled around and near the end. The lateral edges are sharp, as though intended for cutting, and as it might have been used without a handle, if desired, it probably combined two implements, as was so frequently the case. Scrapers of this form are usually thin and flat, but are a little thicker at the broad end, and are also neatly chipped on the lower surface. Many are much smaller than this specimen, and some have the point turned to one side.

Among other remarkable scrapers are some from Canajoharie, found along the river bank. Fig. 189 represents a long form of these. They are not many in number, and have been reported

nowhere else. They vary from almost triangular to nearly circular. This one is of common flint, with conspicuous but obtuse serrations at the broad end, and is one and one half inches long. Some others there are much more finely and sharply serrate, but this serration is along one of the longer sides. They probably had some local use.

A very remarkable class of scrapers, combining the knife with these, occurs in but very moderate numbers, and somewhat local at that. They may be nearly straight, or very much curved, and there is usually a tang at the base, resembling a handle, drawn out into a shoulder on each side. They are quite likely to have been used in fashioning bows and arrows, for which the combination of a convex knife with a concave scraper admirably fitted them. Perhaps less than a dozen have been found in New York. Fig. 190 is a perfect example from the Seneca river, made of brown and drab flint, and three inches long. This is the typical form, much like that of a curved sword with its cross hilt. One much more curved, but unfortunately a little broken, is from Brewerton. It is of common hornstone, two and one half inches long, and has the deepest curve of any yet reported. Out of several which do not essentially differ from these, may be mentioned one of a gritty brown flint, which is one and one eighth inches long. Fig. 191 represents this, which came from the Oswego river. At the point there is a knob-like expansion. A very odd one comes from Cross lake, and is made of a light grey flint, one and seven eighths inches long. It is more angular than others, but the blade does not present so decided a curve. In others the scraper edge is quite as decidedly developed, and they grade into nearly straight forms with the same features. In all the concave edge of the blade is quite thick, while the convex edge is comparatively thin and sharp. In the supplement to his illustrations of the Smithsonian collections, Dr Rau figured a fine example from Ohio, about two inches long, but they are not described by Abbott among New Jersey articles, or by Fowke among those farther west and south. None have been reported in Canada, and they seem practically a New York implement, local even there. The advantage of the combination and the peculiar form will be readily seen.

A still rarer form, in fact quite unique, is one which did not return from a scientific mission, greatly to the owner's sorrow. Fig. 192 is

some reference to flint, or *kahnhia.* A little later Father Bruyas defined the Mohawk *gannohouagethon,* to scrape a hide, and another word expressed the stretching process. In a rude way they are still, or were recently, in use among some of our western indians, but not in forms like those of old. The Eskimo still use them, inserted in handles, and one specimen here figured is almost exactly like those which they make.

Dr Abbott says of New Jersey scrapers, 'One feature of the European scrapers is having one side flat or uniform, the result of the breaking away of a large flake, thus giving on one side the smooth surface of a single plane of cleavage. We have all our specimens chipped upon both sides, unless it be those of about the minimum size, which appear absolutely identical with the European specimens.' In New York, however, a large proportion of the larger examples have this single cleavage, while full chipping on both sides is confined to a few. From Sir John Lubbock's illustrations, Dr Abbott also thought European specimens rudely chipped in comparison with American, and a similar comparison would show the high character of those of New York.

As regards their distribution no exact statement can be made. In some form they seem distributed throughout the world, but the proportion in any collection will vary according to the field in which it has been principally made. Mr Douglass has 220 New York scrapers, out of a total of 1061. Of these 636 came from Missouri, and 71 from Arkansas. From the New England states he has none at all. Dr Rau figured them only from Ohio and Texas. In the Wagman Saratoga collection none are mentioned, but such omissions may be due to their frequent lack of beauty. In a show collection they might make a poor figure.

SERRATE ARROWS

The serrate arrow forms, which Evans called saws in Great Britain, are quite rare in New York, but are common farther west and south. The materials of which the few found here are made, point to a distant origin. Fig. 201 is of translucent horn colored flint, one and three quarters inches long, and it comes from Nine Mile creek, some miles

west of Onondaga lake. The base is gone, but this example is given because of its distinctly serrate character. Another broken specimen, of bluish flint, now one and one half inches long, is as serrate, and comes from the same vicinity. Good examples should occur in the southwestern part of New York, but none have yet been reported.

FLINT HAMMERS

Flint hammers have thus far been more frequently observed in the lower Mohawk valley than elsewhere. They are rude nodules of flint, showing traces of hammering, and sometimes of chipping, but were naturally used but little in a land where field stones are abundant. They differ much from the so-called hammer-stones. Fig. 202 shows one from Spraker's basin, which is two and one quarter inches across, and just a third as thick, one broad surface being quite flat. Fig. 203 is more characteristic, and is from the Seneca river. This is one and seven eighths inches long, and an inch thick. Fig. 204 is a smaller one, not far from one and one half inches each way. Smaller ones yet appear. A more remarkable one comes from Onondaga lake, which is two and one eighth inches long. Its peculiar feature is the rough grinding in two contiguous planes at one end. Flint is rarely ground here, but when this has been done the result is commonly a polish. A few chipped hammers of greenstone present nothing worthy of remark, except a slight expansion at one end. They are from three to four inches long. The ordinary hammer-stones, and the common field stones perhaps restricted the use of these ruder implements. The faceted and picked balls of stone, possibly used in war clubs, properly belong in another class.

MISCELLANEOUS

There are many odd flint forms of uncertain character. Fig. 205 represents one of these, being a fragment of some article unknown. It may be the base of a knife, but is strongly suggestive of the fine stone sceptres found of late in Illinois and Tennessee. In that case this would have been the upper end instead of the base. It is of thin, light drab flint, neatly worked, and is yet over three inches long. It is broken where a line of fossils crossed the stone.

Unfinished articles often awaken curiosity, and sometimes reveal the processes by which they were made, and the several stages of the work. This is notably the case with some celts, and unfinished drilling has even yet greater importance. With articles of flint it is more a question of ultimate intention. Fig. 206 is an odd article, which may have been a completed and broken implement, or an unfinished one, just as well. What we call the lower part has been broken, giving an element of uncertainty to the actual or intended form. As it now is, it is two and three eighths inches in length, and is made of common hornstone. One side is flat, and the other neatly chipped over most of the surface, the concave edge being thickest. This might be classed among implements combining the knife and scraper, for the convex edge is sharp. There are hints, also, of a future modification of the form. The striking peculiarity, however, is the rounded point, deeply indented below, as if for suspension. Fragments like this and the last, are often valuable for their peculiar features.

Fig. 207 is a small curved scraper of common flint, about one and one half inches long, which is from Cayuga county. It differs from those already described in having simply an expanded base, without a tang. The curve is greater than usual, and it has been accepted by some as the flint point of an early fish-hook, for which it might have answered, though it seems too short and thick for such a use. On the whole it seems more reasonable to place it among the curved scrapers, for grave objections might be made to the other use, and it certainly closely resembles these.

Fig. 208 is simply a flint pebble of an oval form, split in two and chipped on the flat surface. These pebbles are water-worn, and not very large, although this is one of the smaller sizes. They seem unfinished, although neatly chipped; and in their present condition would serve only for scrapers. This one is from Seneca county, and they are found there and elsewhere, although nowhere frequent.

Fig. 209 is one of the smallest forms of New York arrows, of the class called bird points. It is less than half an inch long, and comes from Tioga county, where they are frequent, but with various outlines. Many think these were made for children, on account of their small size, but they are quite as likely to have had other uses.

FISHING AND STONE NET SINKERS

One very important article in the food of the American aborigines was fish. The accounts which early travelers and colonists give of the abundance of all descriptions of fishes in lakes and rivers, seem wonderful now, when we are trying to restore them to some degree of their early condition, and yet they are harmonious and well supported. The only difficulty the indian had was to preserve and store up this abundant supply for hours of need. In Canada and New York, eels were taken in vast numbers, and were easily preserved by smoking. It does not appear that this was usual with fish of other kinds. Salt they did not use, and it was distasteful to them. The Iroquois now ascribe their degeneracy and lack of manly vigor, to using salt meat, instead of obtaining all its fresh juices, as their ancestors did.

It becomes a matter of interest to know how they took the fish which swarmed in every stream, for certain relics have direct reference to this. In doing so, however, bare allusion will be made to harpooning, for the harpoon of colonial times was made of bone or horn, and sometimes of wood and iron, thus lying outside of those chipped stone implements to which this paper relates. Only incidentally will angling be touched upon, for the same reason.

In the account of Champlain's voyages, that great discoverer told of Huron customs. 'The men make the nets to capture fish in summer as well as in winter, when they generally fish, reaching their prey even below the ice, either with the line or the seine.' This winter fishing was described by others as well as Champlain, but he mentions the fact which is of importance here, that the net 'sinks to the bottom of the water by means of certain small stones attached to the end.' While Sagard describes the making of Huron nets and their use, he says nothing of these weights, for the one was a necessity of the other. He does, however, allude to one fact in angling, which is important if we substitute the curved and slender stone drill for the piece of bone. He said, 'We found in the bellies of several large fishes, hooks made of a piece of wood and a bone, so placed as to form a hook, and very neatly bound together with hemp.' A figure has been given of a New York stone perforator, suitable for this use. The

Canadian institute has several well adapted for this also, varying from two and one quarter to four inches in length. The early Huron practice of marrying the nets to two young girls, is well known, and seemed long established when the French first met them. The Algonquins had an old story that Michabou taught their ancestors how to make nets, having taken the hint from watching a spider catch a fly. Nets were therefore plainly an aboriginal invention, and their use is directly connected with the large numbers of flat net stones found by all considerable streams. These nets were made of native hemp, out of which some of the New York Iroquois still make thread in their primitive way.

Mr William L. Stone gave Dr Rau an 'account of a stone structure, evidently a fish-pen, in the state of New York.' It was on the right or south bank of Fish creek, the outlet of Saratoga lake, and the plan and description will be found on page 201, of *Prehistoric fishing*. It is a matter of considerable interest, and Mr Stone readily disposes of a seeming difficulty, the fact that the opening to the pound was down stream, by supposing that it was employed mainly when the fish were ascending the creek to spawn. Such pounds were frequent among the indians elsewhere within historic times, made of stones or wood, and there is no great difficulty in assigning such a use to this. In Sullivan's campaign, in 1779, a town was destroyed on the present site of Waterloo, where were 'several fish ponds abounding opposite the town.' This was the statement of Sergeant Major George Grant. Gen. John S. Clark, a well known antiquarian made a note on this: 'These were circular enclosures of stone from 30 to 40 feet in diameter, built upon the rocky bed of the stream, where the water was neither very deep or rapid, so constructed as to permit the water to pass through, but to retain the fish.' These, of course, were simply places for keeping surplus stock.

These were modern structures. When the famous 'Lessee company' made its agreement with the Six Nations in 1787-88, the indians reserved 'one half of the falls and convenient places for weirs, for the purpose of catching fish and eels, from Cross lake to the Three Rivers.' Without questioning whether eels are fish, it is clear that the Iroquois attached importance to the use of weirs, and that some

might be even now looked for in the waters mentioned. When Francis A. Vanderkemp descended the Oneida river, in 1792, at one rift he remarked, 'It was said here was an ancient indian eel-weir — by which this natural obstruction in the bed of the river had been increased.'

Several such stone weirs still remain in the Seneca river, in a more or less fragmentary condition. One which is several hundred feet in extent, runs in a zigzag way across the river, and two deep bays are in excellent order. The third was removed to permit the passage of large boats. The French missionaries mentioned such structures here in 1656, in these terms: 'The fish which are most common here are the eel and salmon, which are fished for from the spring until the end of autumn, our savages managing so well their dykes and weirs, that they take at the same time the eel which is going down, and the salmon which is going up.' They also speared fish by torchlight, but often used a peculiar wooden spear for this. Fifty years earlier they had bone harpoons.

There are several early accounts of the use of these fish-weirs, in various parts of the country, and Loskiel gives that which was common in Pennsylvania, when the shad ascended the rivers. 'The indians run a dam of stones across the stream, where its depth will admit of it, not in a straight line, but in two parts, verging towards each other in an angle. An opening is left in the middle for the water to run off. At this opening they place a large box, the bottom of which is full of holes. They then make a rope of the twigs of the wild vine, reaching across the stream, upon which boughs of about six feet in length are fastened at the distance of about two fathoms from each other. A party is detached about a mile above the dam with this rope and its appendages, who begin to move gently down the current, some guiding one, some the opposite end, whilst others keep the branches from sinking by supporting the rope in the middle with wooden forks. Thus they proceed, frightening the fishes into the opening left in the middle of the dam.'

Though their use may be inferred in this, nothing is said of stone sinkers. In another account, published by Adair in 1775, there are mentioned on the vine, 'stones attached at proper distances, to rake

the bottom.' This was another use of the flat stone sinker, differing slightly from its use in nets. The polished and grooved plummets, so distinct from these, had other uses, though notably most abundant at two early fishing resorts. The grooved pebbles were many of them sinkers.

It may be remarked that the Hurons and others placed hurdles in streams, with nets across the openings, and that the Oneidas in New York made fish pounds with two rows of stakes across streams, driving the fish into them and killing them there.

The flat stone sinker was easily made by the aborigines, and in fact is still made and used by their white successors. A small flat stone was found and neatly chipped around the edge, or sometimes left almost unchanged. As a sinker it might have two to four opposite notches by which it could be attached more securely. If used as a quoit, the notches might be omitted, and the whole surface neatly chipped. This was the sole difference between these two forms, which might be large or small in either case. Occasionally a small and thin smooth pebble is found on a village site, not over an inch across and with two opposite notches cut in the edge. These have no relation to either of the preceding forms. There are also grooved and chipped stones of considerable size, which were used for anchors, but these are somewhat rare. A series of grooved elliptical pebbles may be classed with those of picked stone, although probably net sinkers. They occur most frequently on Cayuga and Seneca lakes.

Some of the flat sinkers are quite large. Dr Rau figured one which was eight inches across, and one and three eighths inches thick, the weight being two pounds and fourteen ounces. Dr Abbott found one on the Delaware river, which was eight inches square, and had four notches. The weight was nearly five pounds. Here they are rarely much over six inches across, when of the typical form. One fine one, however, unwrought except by the slight notches, is nearly seven inches across, and two and three quarters thick. It may have been used for an anchor, for which it is well fitted in every way.

While abundant near many fishing places on the land, heaps of them have been found in Onondaga lake below the present low water mark, itself the result of drainage. The unnotched forms are

found on village sites, more or less remote from water, and undoubtedly were some form of quoit, or they might also have been used somewhat like the southern chungke stone. They occur in many places where they have attracted little or no attention. Fig. 211 represents an example, made from red sandstone. This has no notches, and was found on a village site in Cayuga county, four miles from any water where nets could have been used. Notched forms, however, occur in earthworks from one and a half to three miles from water. Fig. 212 is a good example of the notched form, three and seven eighths by four and one quarter inches. This is a grey sandstone sinker of medium size, from Cross lake, and is rather thin. The larger sinkers usually have four notches. Grooved sinkers or anchors of the larger and ruder forms scarcely require illustration. One of coarse sandstone comes from Brewerton, and is six inches long by four and one quarter wide, the thickness being three inches. On the flattened surface, lengthwise, a broad and deep groove goes all the way around. Few worked anchors are found.

This is a summary of the leading forms of chipped stone implements found in New York. They preceded and survived the finer articles of polished stone, which is naturally the next subject to be treated, and of which New York furnishes so many good examples. That every important locality will yield striking varieties of chipped implements not here illustrated, is to be expected. The purpose of such a paper is to furnish information, but yet more to be a basis for comparison, so that collectors may judge of the real value of the articles they find, and thus be induced to contribute rare specimens to this department of the state museum.

In conclusion it may be said that the value of many articles depends greatly upon the places where they were found, and that a good record of localities is essential to scientific progress. A good local map, on which sites may be placed; a book of outlines, however rude, with descriptive notes, will aid greatly in doing a noble work for the people of New York. These every collector should have.

EXPLANATION OF PLATES

Fuller descriptions are given in bulletin. For exact page reference see index under *Plates*.

Arrow-heads

FIG.	MATERIAL	LENGTH IN INCHES	WIDTH IN INCHES
1	Drab hornstone	4	....
2	Mottled flint	1	1
3	Brown "	......	1⅜
4a	Dark "	......	1¼
4b	Drab "	......	1 11/16
4c	*a*............	......	....
5	Dark flint	1¼	....
6	Drab "	2½	....
7	Drab "	2	....
8	Common "	1⅛	....
9	Mottled "	2	....
10	Grey "	1¼	....
11	Grey "	......	....
12	White "	......	....
13	Lustrous "	2⅛	....
14	Bluish-grey "	2½	....
15	Common "	1¾	....
16	Dark "	2¼	....
17	Common "	2	....
18	Common "	1¾	....
19	Stone	1½	....
20	Grey flint	1¾	....
21	Common "	1½	....
22	Common "	2¾	....
23	Brown flinty sandstone...	1⅜	....
24	Dark blue flint	1¼	....
25	Lustrous jasper	1⅞	....
26	Grey flint.....	1⅞	....
27	Yellow jasper..	1	....
28	Flint..........	1¼	....
29	*a*............	......	....
30	Yellow jasper..	¾	....
31	White flint	2⅛	....
32	Common "	1½	....
33	Brown "	1¾	....
34	White "	1⅝	....
35	Drab "	1⅛	....
36	Drab "	1⅛	....
37	Grey limestone	2	2—
38	Common flint..	1½	....
39	Yellow jasper..	1	....
40	Black flint....	1⅝	....
41	Shark's tooth..	1½	....
42	Grey flint	2½	....
43	Common "	2½	....
44	Blue "	......	1½ at base
45	Common hornstone.......	......	1¼ at base
46	Drab flint	1½	....
47	Drab "	1¾	....
48	Brown "	1¾	....
49	Brown "	1½	1 3/16
50	Brownish-white flint	1⅝	....
51	Brown flint...	1⅞	....

FIG.	MATERIAL	LENGTH IN INCHES	WIDTH IN INCHES
52	Common hornstone.......	2¼	1⅜ at base
53	Drab flint	1 5/16	....
54	Brown "	1+	....
55	Brown hornstone.......	1 5/16	....
56	Dark-blue flint	2	....
57	Common "	2	....
58	Light brown "	1¼	⅞ at base
59	Drab "	2½	1⅝
60	Light color'd "	1—	....
61	Dark "	1	....
62	Light bluish "	1½	....
63	White "	1⅛	....
64	Dark blue "	1	....
65	Drab "	⅞	....
66	Drab "	1	....
67	Drab "	2	....
68	Common "	1⅞	....
69	Drab "	1¾	....
70	Drab "	2¼	....
71	Black "	2	....
72	Common "	1¼	....
73	Dark "	1⅞	....
74	Dark "	2½	....
75	Dark hornstone	2⅛	....
76	Dark flint	2	....
77	Light "	1¼	1½
78	Brown "	2¼	....
79	Drab "	⅞	....
80	Black "	1½	....
81	Dark "	1¼	....
82	*a*............	1⅛	....
83	White quartz..	2	....
84	Drab flint	2¼	....
85	Blue "	2⅛	....
86	Common hornstone	1¾	....
87	Olive slate....	......	....
88	Drab flint	2¼	....
89	Brown "	1	....
90	Drab "	1⅛	....
91	Dark "	1¼	....
92	Dark "	1⅜	....
93	Dark "	1½	....
94	Common "	1+	⅞
95	Grey flinty limestone ...	2⅜	....
96	Red jasper....	1½+	....
97	Blue flinty limestone....	1⅝	....
98	*a*............	2⅛	....
99	Purplish flint..	2	....
100	Common hornstone.......	1	....
101	Dark blue flint	2	1¼

a Not given

EXPLANATION OF PLATES, *continued*

Spear-heads

FIG.	MATERIAL	LENGTH IN INCHES	WIDTH IN INCHES	FIG.	MATERIAL	LENGTH IN INCHES	WIDTH IN INCHES
102	White flint	6½	....	114	Resembles moss agate..	3½	....
103	Grey "	5⅛	....	115	Flint.........	4¼	1—
104	Black "	5⅝	....	116	Grey flint.....	4¼	....
105	Common "	7	....	117	" quartzite (?)	5½	....
106	Translucent quartz......	4⅞	2	118	Variegated hornstone...	2⅛	....
107	White mottled quartz......	3⅝	1 5/16	119	Resembles moss agate..	5+	....
108	Green jasper..	9 from base[b]	4 at base	120	Greenish white flint........	4⅜	....
109	Drab flint	3¾	1⅝	121	Common hornstone.......	2⅝	....
110	White translucent quartz..	....	....	122	Hornstone....	3⅛	....
111	Drab flint	3 7/16	1⅛	123	Blue grey flint	7¼	....
112	Common "	6	2	124	Chalcedony...	4⅛	2
113	Grey flinty limestone...	6+	1¾	125	Drab flint....	2⅞	1⅛

Knives

126	Grey flint.....	3¼	....	137	Brown flint	3⅝	....
127	Yellow jasper	3¾	2	138	Brown "	2½	....
128	Drab flint	4	....	139	Brown "	3	....
129	Light blue "	5	....	140	Variegated "	2	....
130	White "	3	....	141	Common "	2¾	....
131	Common "	1⅝	....	142	*a*	4½	1⅛
132	Dark blue "	1⅝	....	143	Grey limestone	3⅝	1¼
133	Grey limestone	2	....	144	Hornstone....	5	2¼
134	Clouded quartz	6½	2	145	Common flint..	3½	....
135	Brown flint	3¼[b]	....	146	Bent arrow form.......	......	....
136	Brown "	3¼	....				

Spades or hoes

147	Bluish grey stone.....	11¼	5¼	149	Grey flint.....	4	....
148	Common flint	3¼	....	150	Orange jasper	5	3¼
				151	Red sandstone	5⅞	3⅜

Chipped stone axes

152	Brown sandstone.......	5⅝	....	156	Drab flint....	2¼	....
153	Ferruginous flint........	5⅛	3¾	157	*c*..........	......	....
154	Common hornstone	2¾	⅞	158	*c*..........	......	....
155	Grey flint....	2	1	159	Brown flint...	4	....
				160	Common hornstone.......	2½	1⅛
				161	Clouded quartz	2⅞	2

Perforators

157	Common flint	3	3+	169	Drab flint	1⅛	....
158	Bluish "	1—	....	170	Black "	2½	....
162	Brown "	3¾	....	171	Grey "	2½	....
163	Yellow shaded to red......	3¾	....	172	*a*..........	......	....
164	Mottled flint	2½	....	173	Drab flint	1½	....
165	Grey "	3⅞	....	174	Drab "	1¼	....
166	Light brown "	1⅜	....	175	Dark "	1⅞	....
167	Common "	1¼	....	176	Common hornstone.......	2⅝	....
168	Brown "	2	2—				

a Not given *b* Fragment. Length unknown *c* See under *Perforators*

EXPLANATION OF PLATES, *concluded*

Scrapers

FIG.	MATERIAL	LENGTH IN INCHES	WIDTH IN INCHES	FIG.	MATERIAL	LENGTH IN INCHES	WIDTH IN INCHES
177	Broken arrow head......	....	....	189	Common flint	1½	....
178	Brown flint	2⅝	....	190	Brown "	3	....
179	Brown "	2⅞	....	191	Brown "	1⅛	....
180	Dark "	1	1	192	Green jasper..	1⅞	....
181	Hornstone....	....	1	193	Grey flinty limestone ..	2	....
182	Hornstone....	....	1—	194	Brown flint	1⅛	....
183	Common flint	⅞	....	195	Hornstone....	⅞	1¼
184	Drab "	1⅜	....	196	Drab flint	1½	1½
185	Brown "	1⅛	....	197	Brown "	1⅛	1¾
186	Brown "	5½	....	198	Black "	1	1+
187	Brownish grey flint.........	4⅛	1	199	Dark "	⅞	....
188	Dark blue flint	2	....	200	Dark "	1¼	1

Serrate arrow

FIG.	MATERIAL	LENGTH IN INCHES	WIDTH IN INCHES	FIG.	MATERIAL	LENGTH IN INCHES	WIDTH IN INCHES
201	Translucent fl't	1¾	....				

Flint hammers

FIG.	MATERIAL	LENGTH IN INCHES	WIDTH IN INCHES	FIG.	MATERIAL	LENGTH IN INCHES	WIDTH IN INCHES
202	....	....	2¼	204	....	1½	1⅛
203	....	1⅞	....				

Miscellaneous

FIG.	MATERIAL	LENGTH IN INCHES	WIDTH IN INCHES	FIG.	MATERIAL	LENGTH IN INCHES	WIDTH IN INCHES
205	Drab flint....	3	....	208	Flint pebble..	....	....
206	Hornstone....	2⅜	....	209	Bird point arrow......	½—	....
207	Common flint	1½	....				

Stone sinkers

FIG.	MATERIAL	LENGTH IN INCHES	WIDTH IN INCHES	FIG.	MATERIAL	LENGTH IN INCHES	WIDTH IN INCHES
210	*a*	....	....	212	Grey sandstone	3⅞	4¼
211	Red sandstone	....	....				

a Not given


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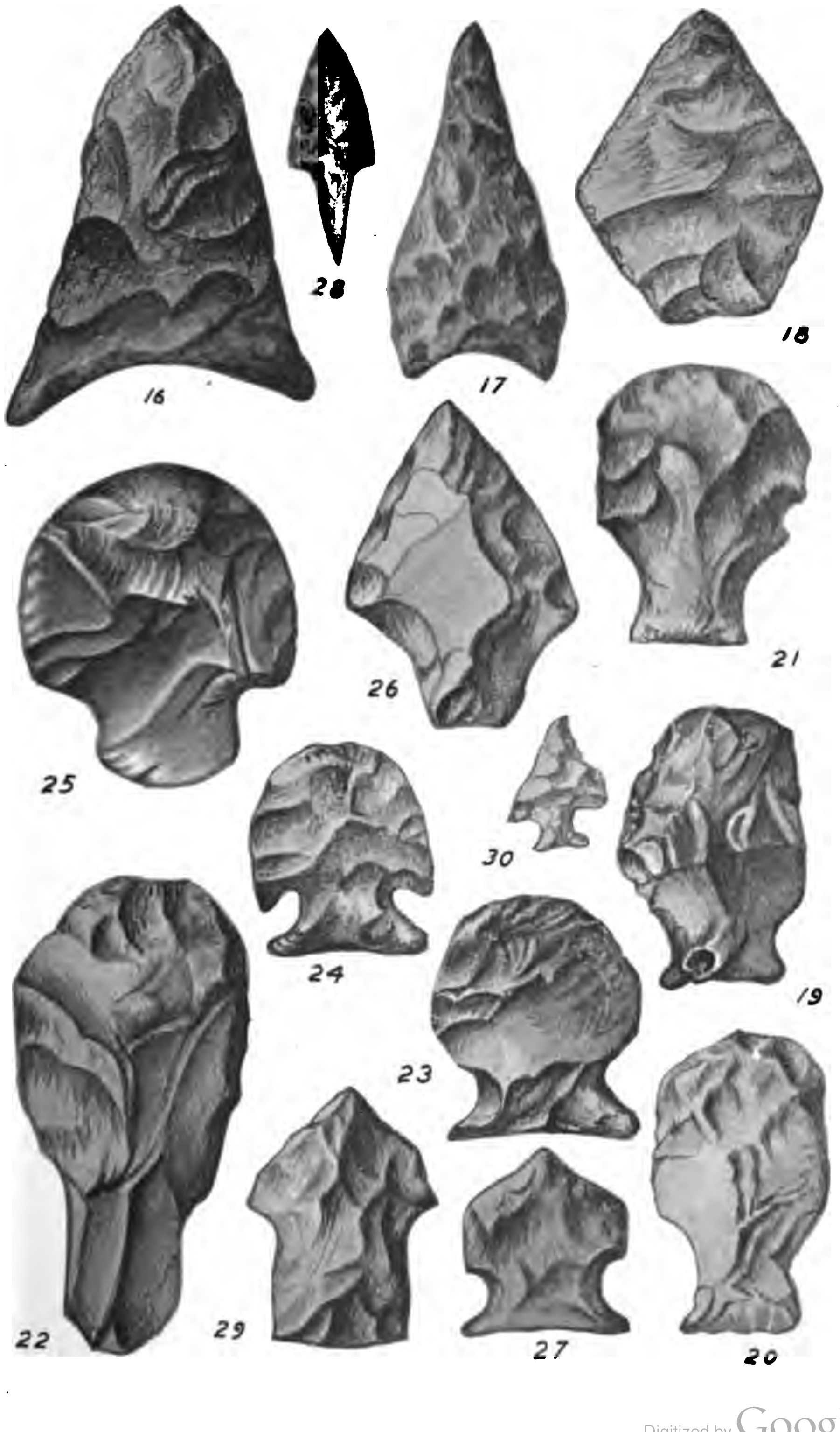
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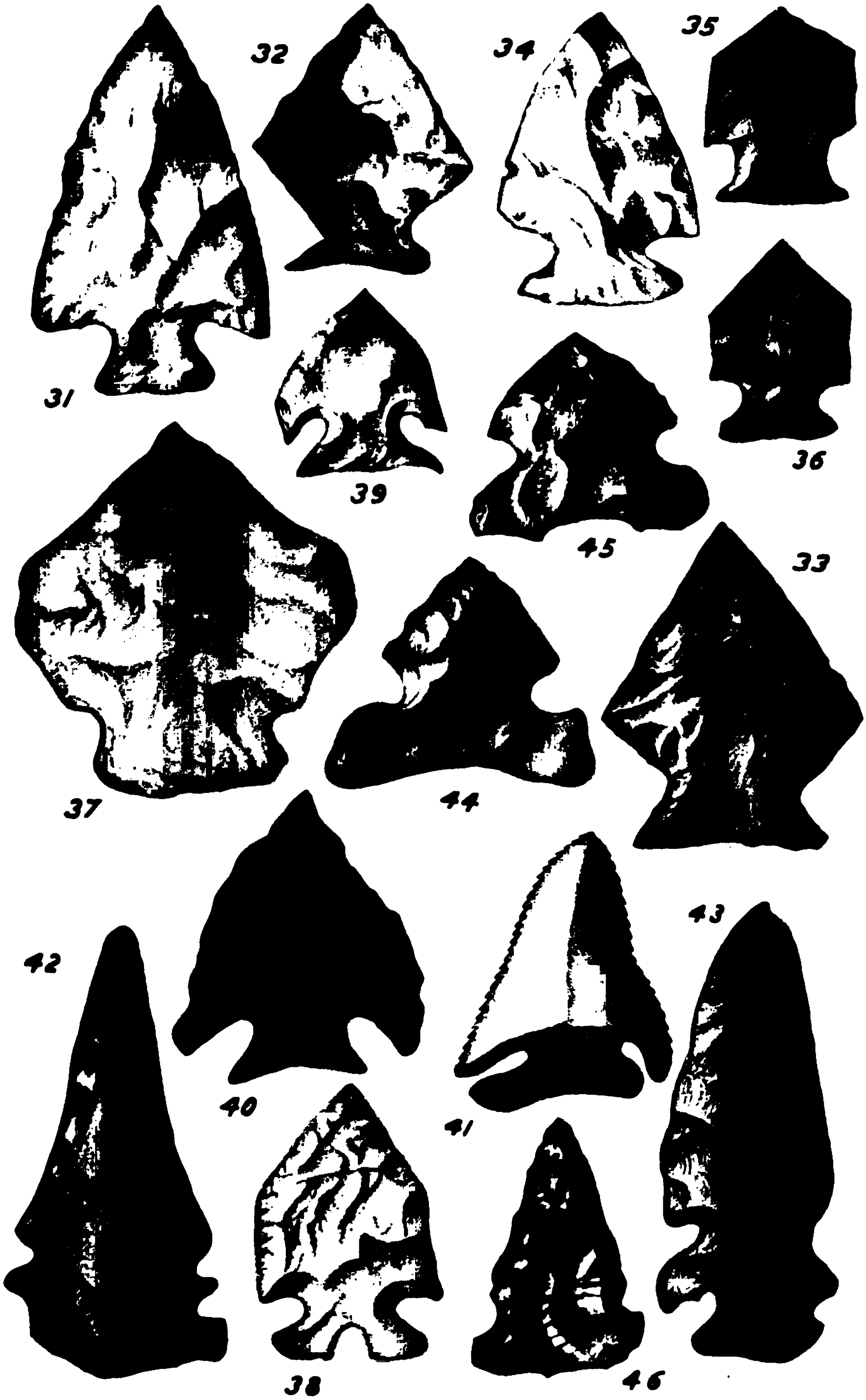
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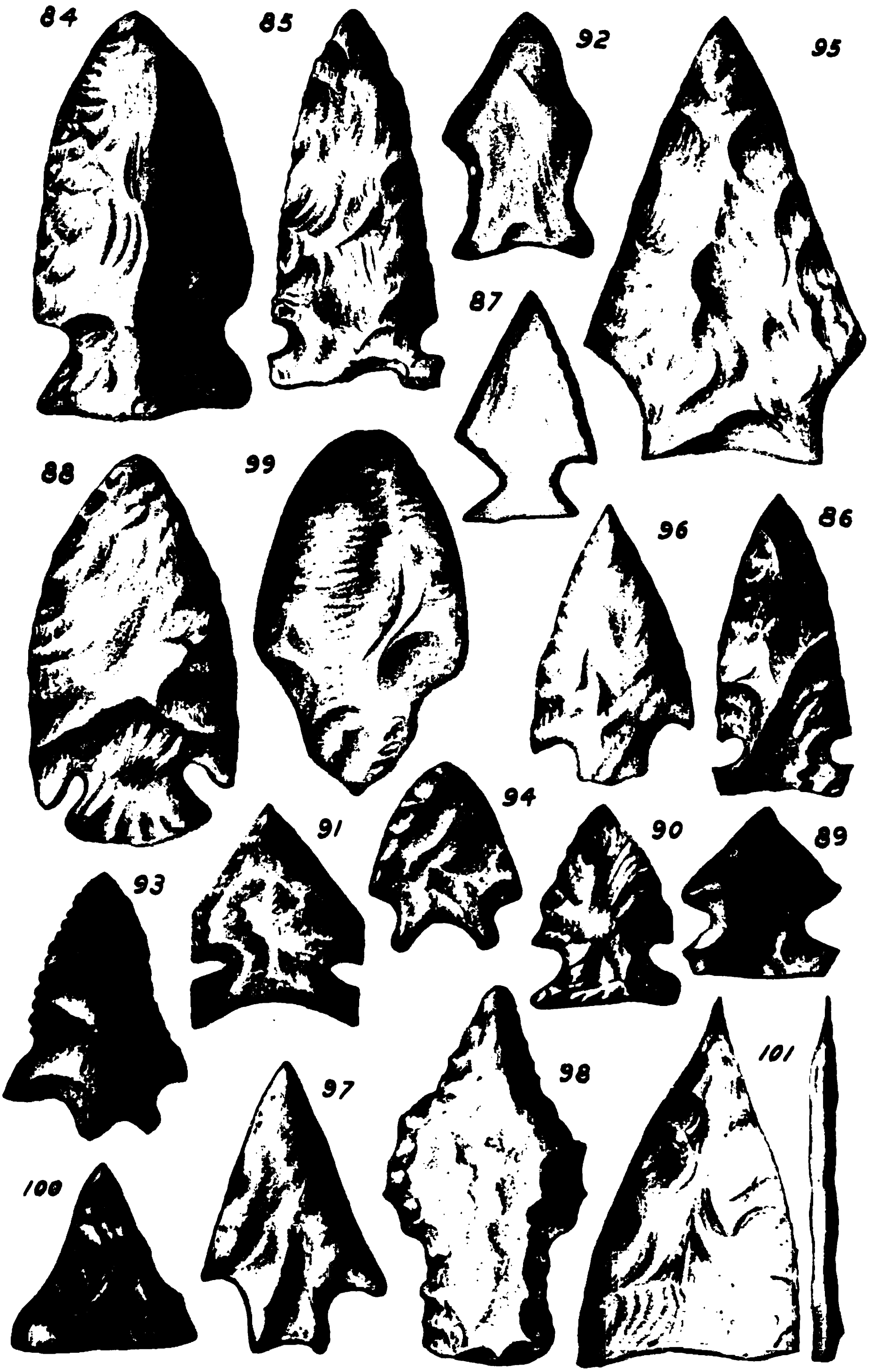
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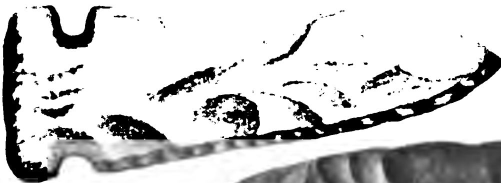

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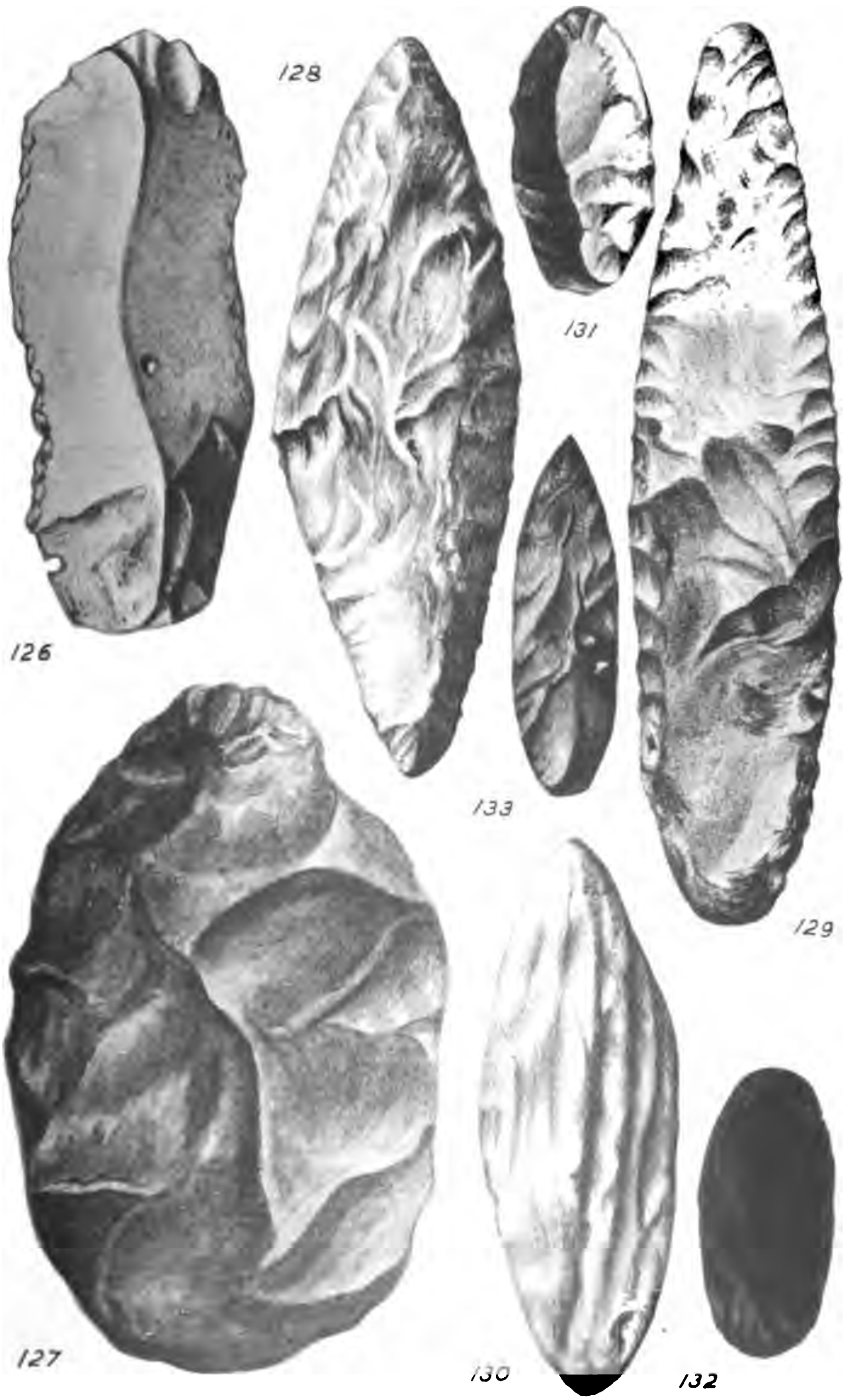
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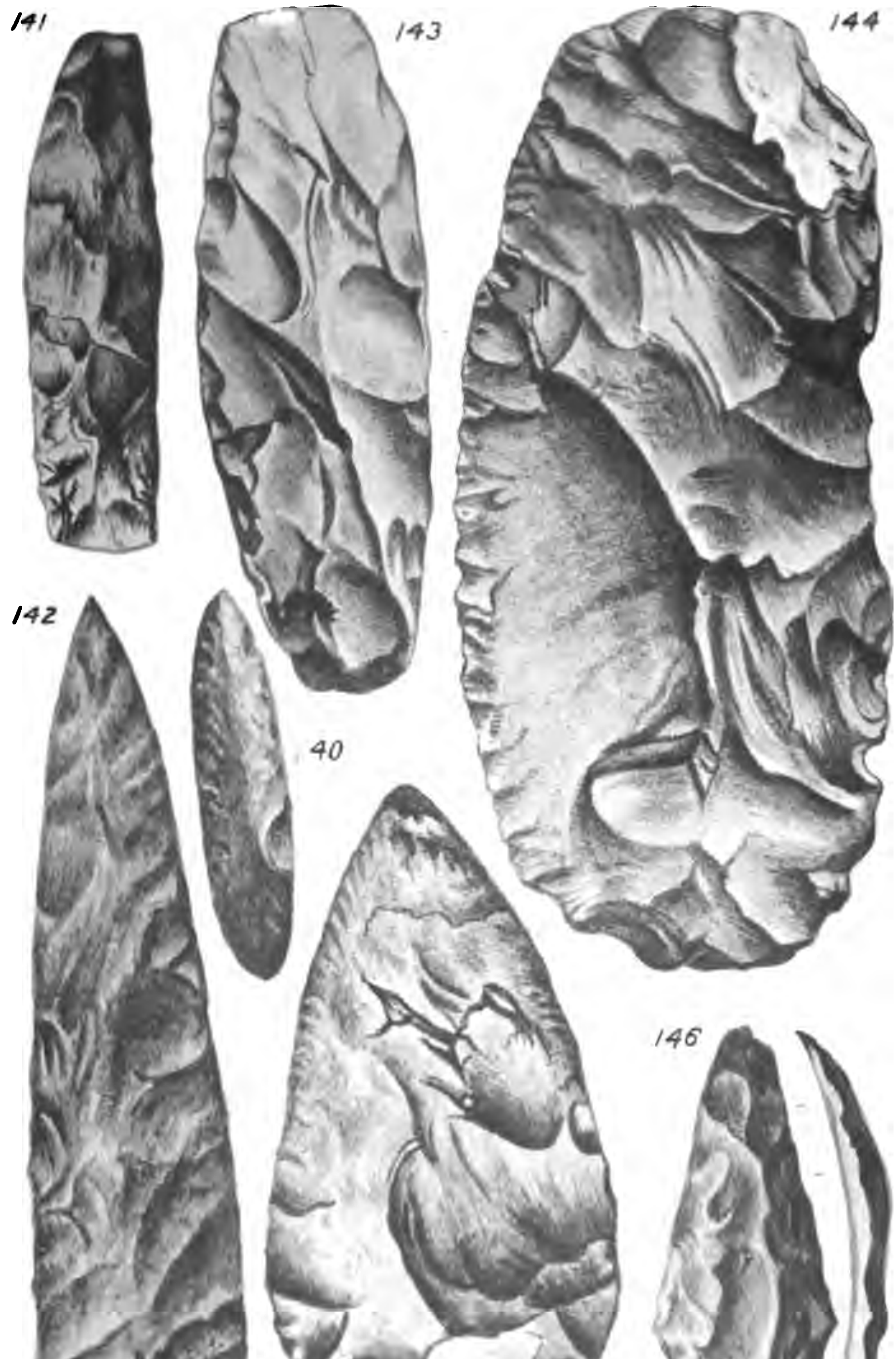
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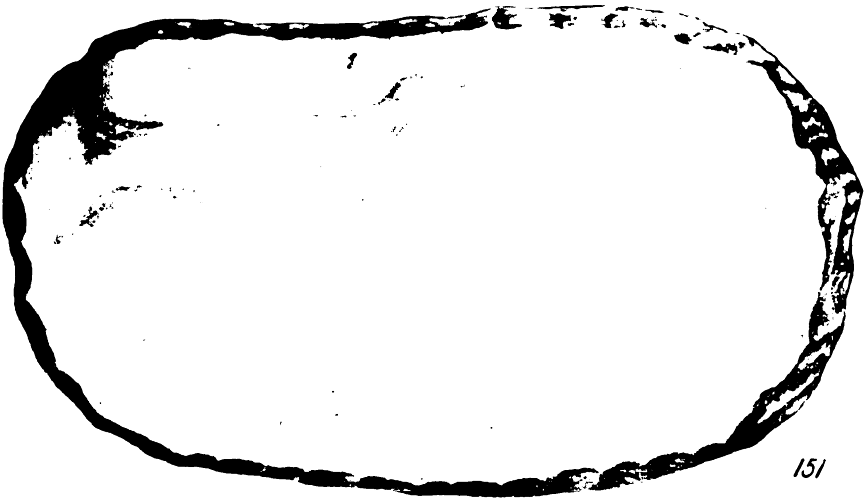

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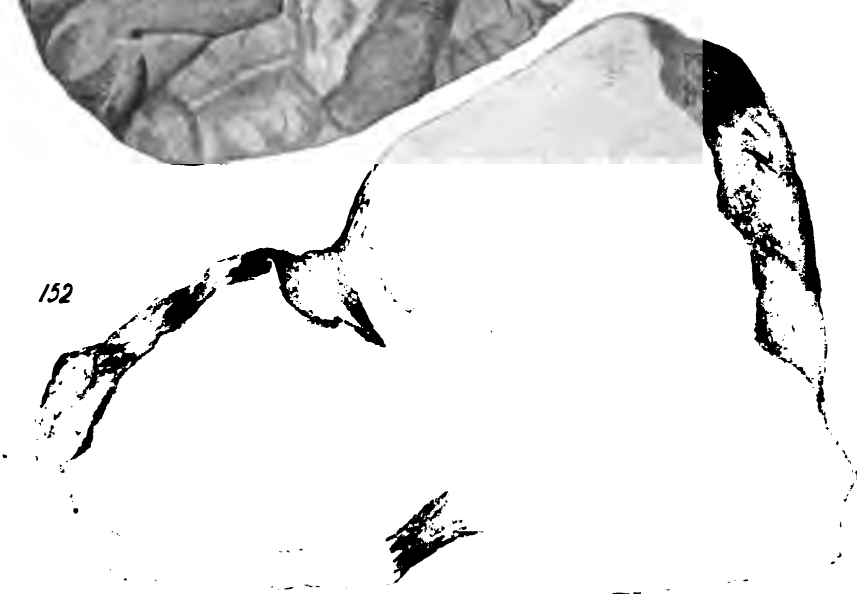

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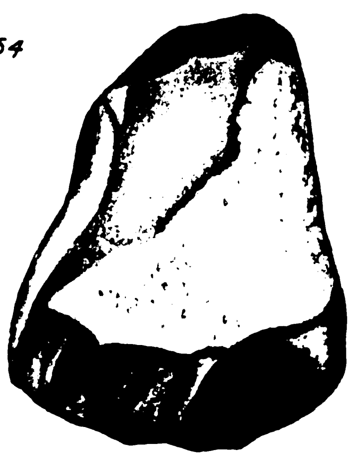

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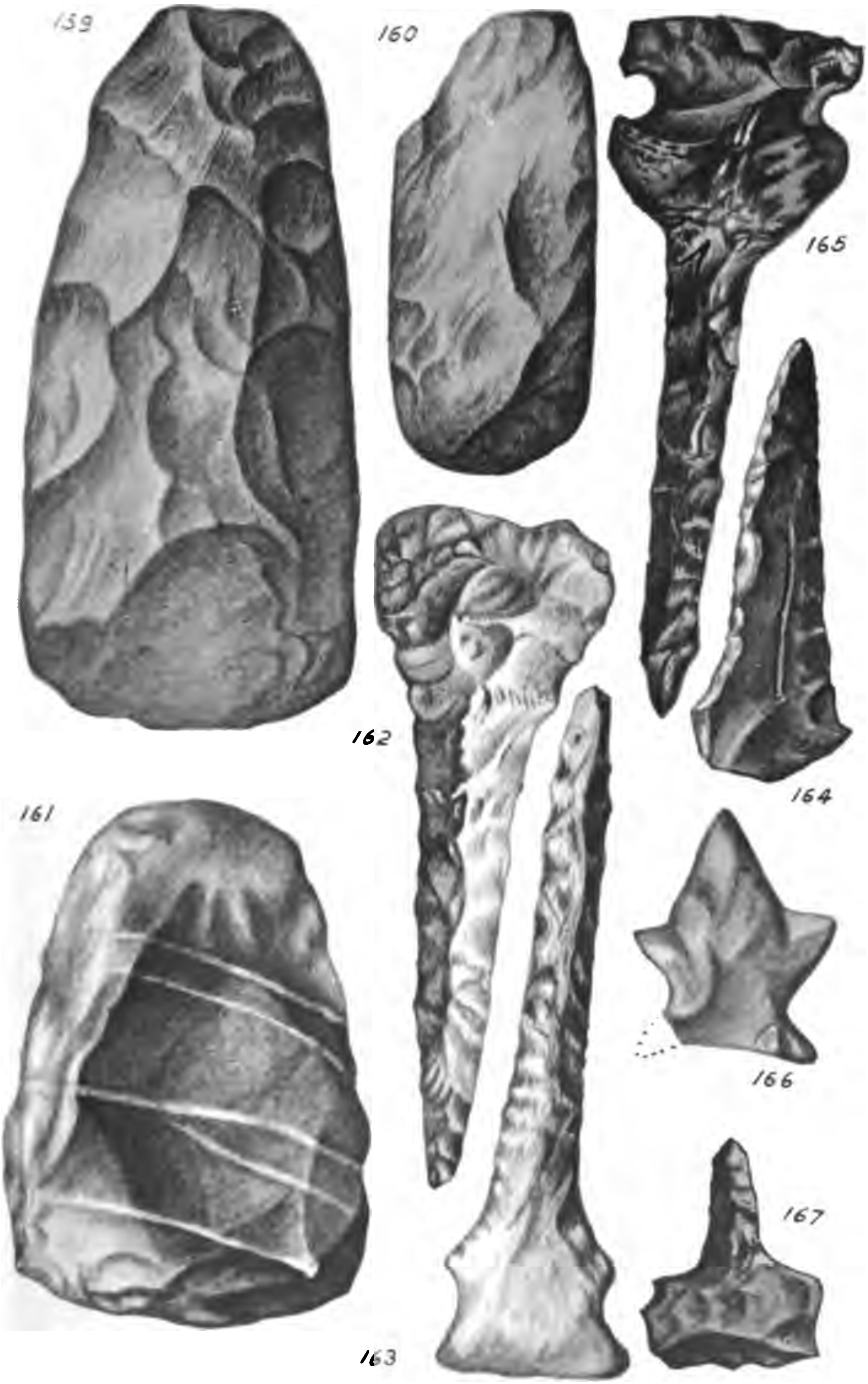
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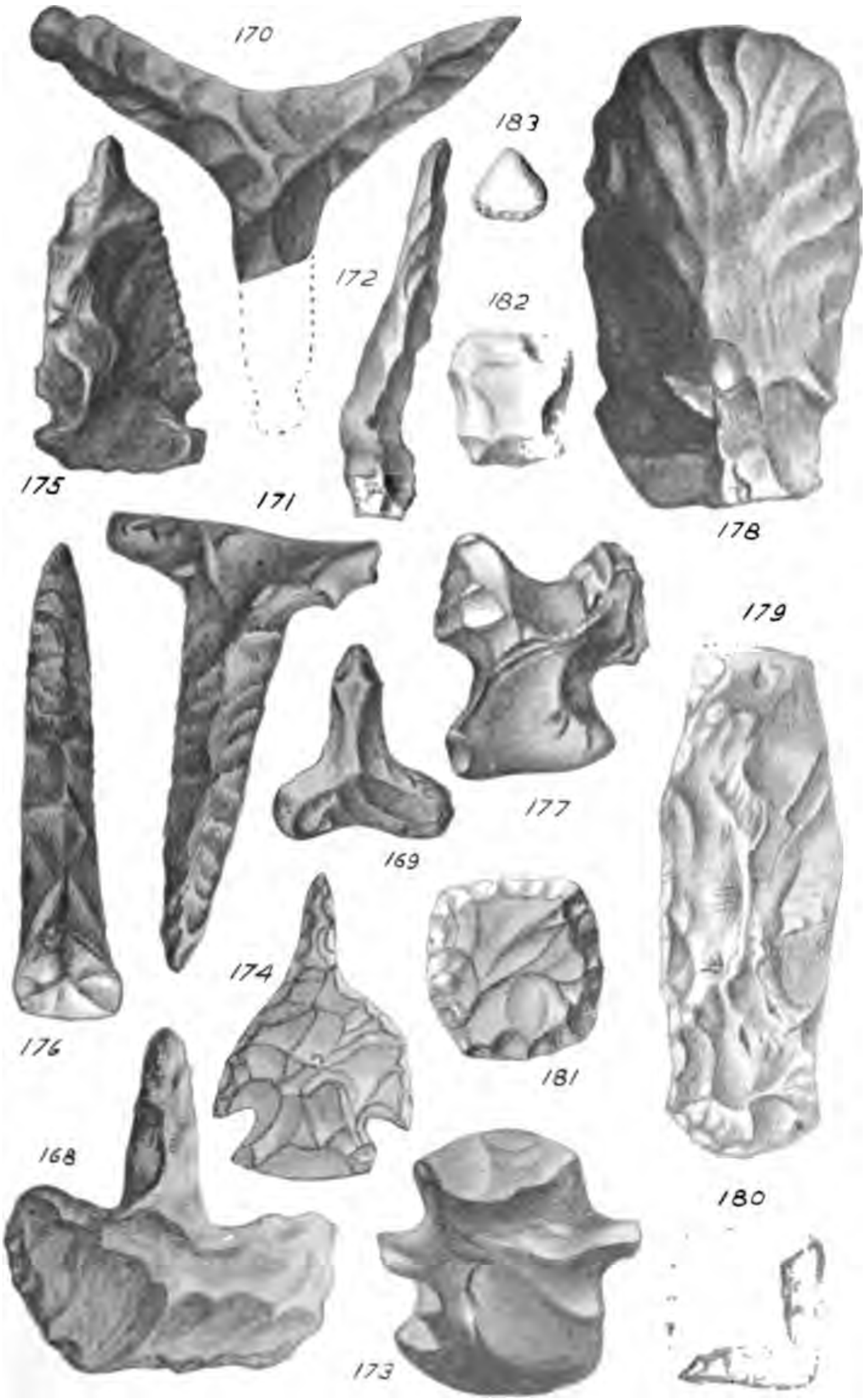
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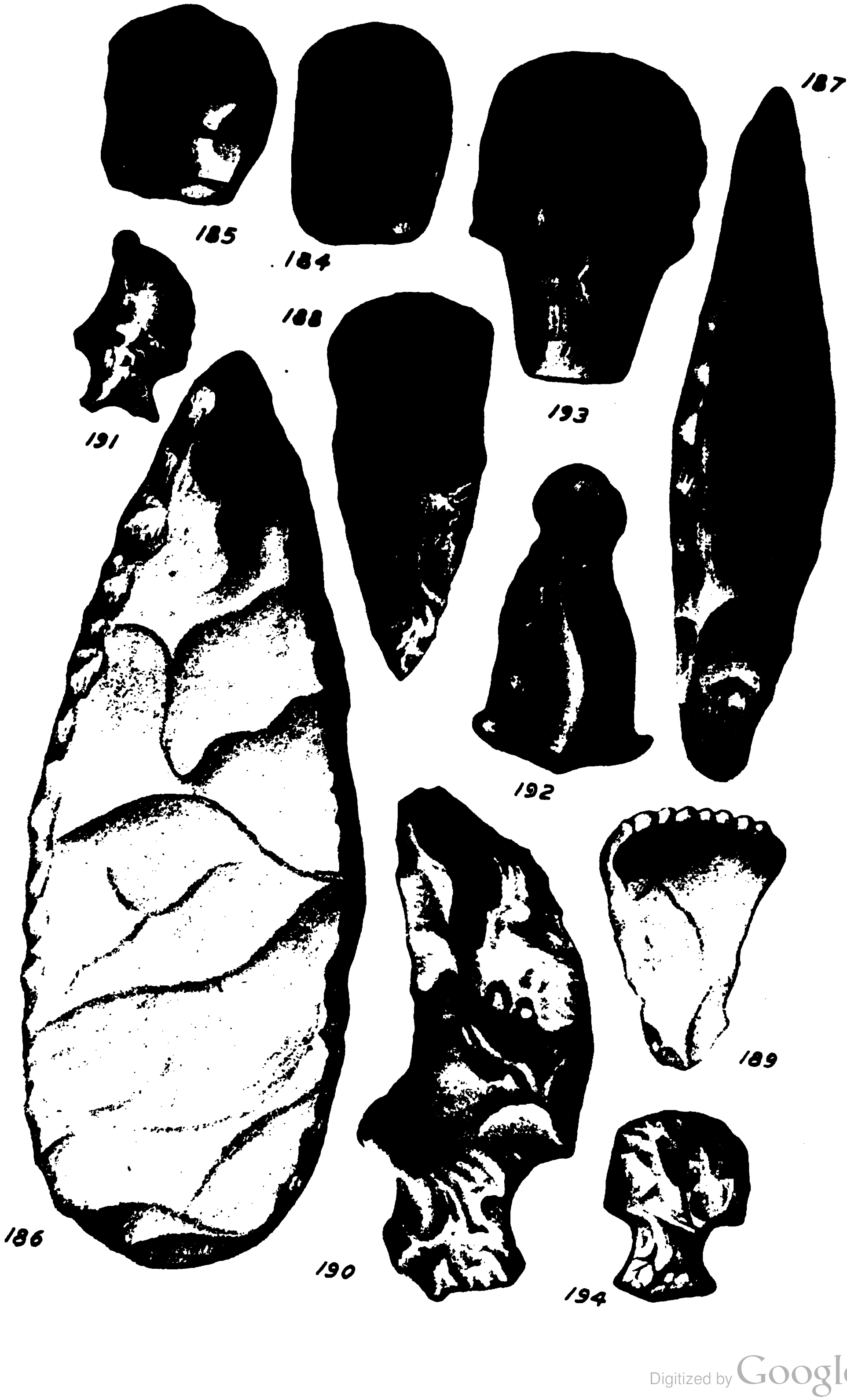
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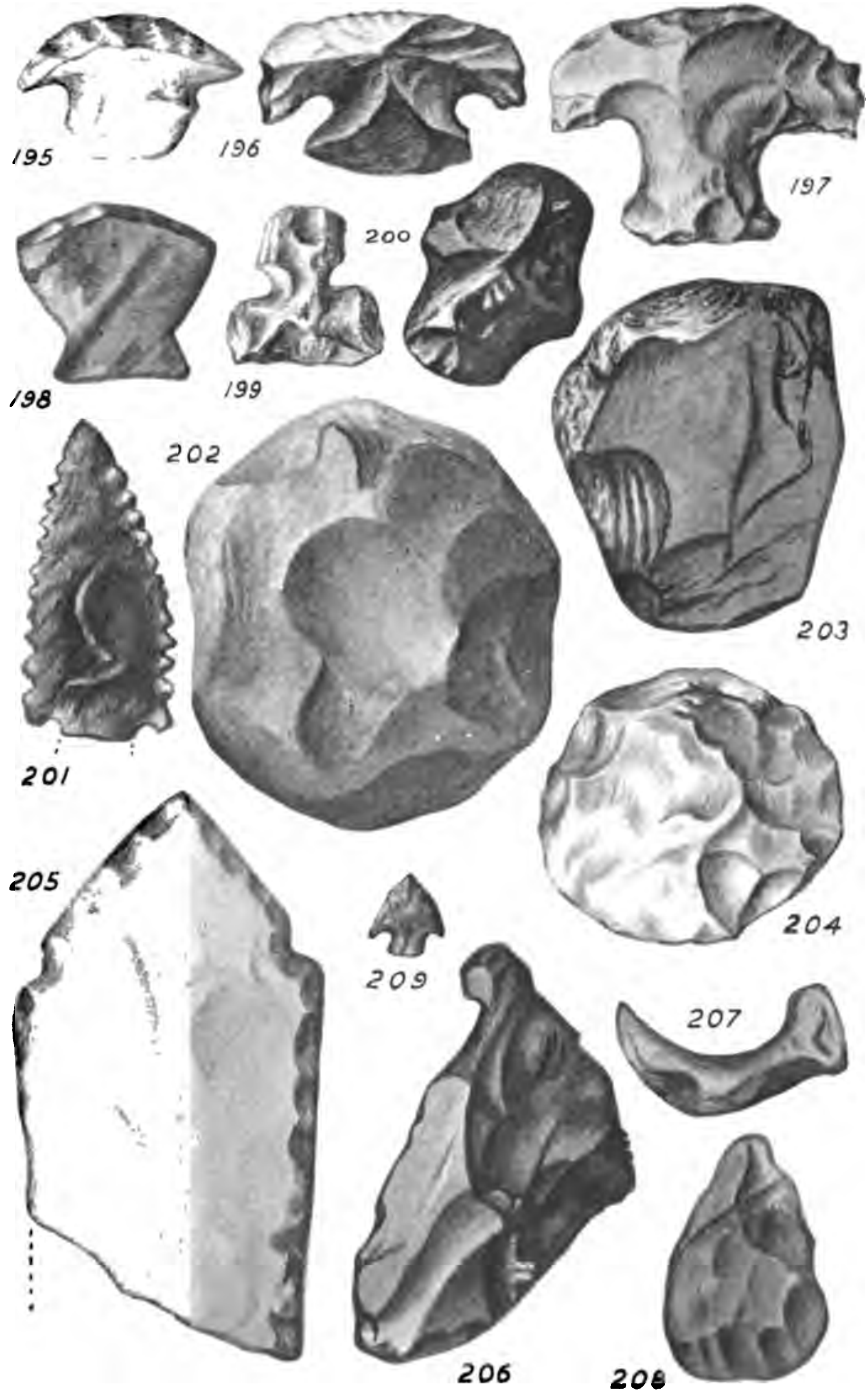
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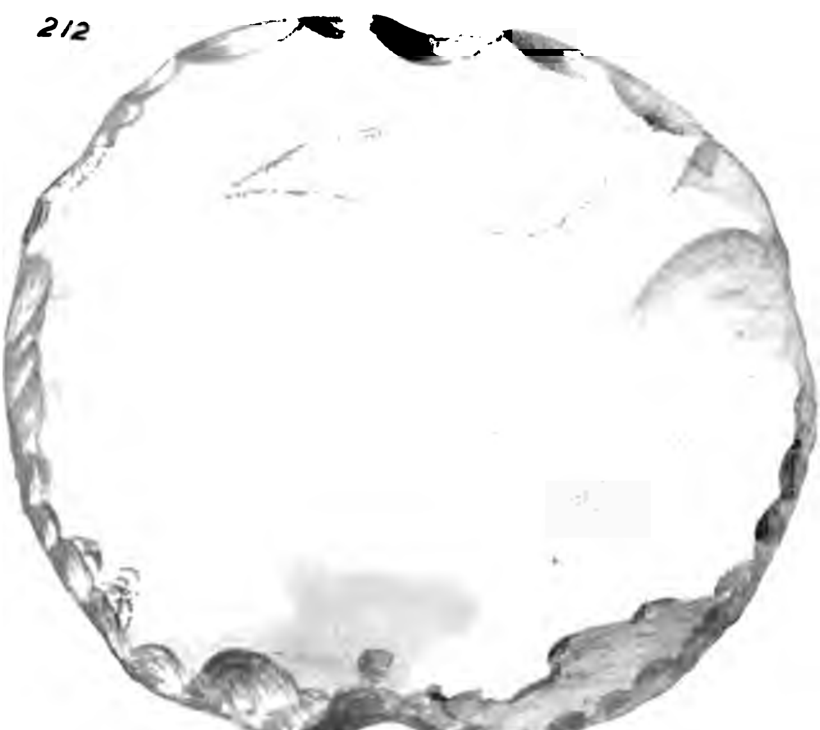


INDEX

The superior figure tells the exact place on the page in ninths; e. g. 5^3 means three ninths of the way down page five.

University of the State of New York

BULLETIN

OF THE

New York State Museum

VOL. 4 No. 17

OCTOBER 1897

ROAD MATERIALS

AND

ROAD BUILDING

IN

NEW YORK

BY

FREDERICK J. H. MERRILL, PH. D.
Director New York State Museum

ALBANY

UNIVERSITY OF THE STATE OF NEW YORK

1897.

Regents

CONTENTS

PREFACE

This bulletin was prepared at the request of the chairman of the state museum committee for a report on the road materials of New York. Having ascertained what might be worth publishing on this subject, it appeared desirable to add a short discussion on the road problem in our state.

It has been the writer's aim to make the pamphlet as brief as possible and therefore easily read. He has endeavored to discuss concisely what appeared to him the salient points of the problem, and his purpose has been rather to bring to public attention, facts not generally appreciated than to discuss matters of common knowledge.

In preparing this report the writer has communicated with about two thousand quarrymen, and has acquired much information concerning local variations in rock used as road metal, but it does not seem pertinent to this preliminary publication to discuss details which might obscure the main points. It seems also inadvisable to publish statements which discriminate between the products of various quarries until further study has established their correctness beyond all possibility of criticism. These details are therefore reserved for future publication.

The report of the special committee on good roads, transmitted to the legislature Jan. 14, 1896, is recommended to the attention of all who wish to inform themselves on the details of the present situation in New York, Massachusetts, Connecticut and other states.

Attention is also called to the publications of the Bureau of Road Inquiry of the U. S. Dept. of Agriculture.

It being impossible with the museum funds at hand to erect a laboratory for the testing of New York road materials, the writer applied for assistance to the Massachusetts Highway Commission, which courteously and generously agreed to test some representative samples of New York road material.

In the following pages the Massachusetts Commission has been quoted exclusively, not from a desire to ignore the work in other states, such as New Jersey and Connecticut, but because the problems in Massachusetts are similar to those in New York, and the Commission in question seemed to have studied and reported on the situation it had to deal with in a more detailed and exhaustive way.

To Prof. N. S. Shaler and the other Highway Commissioners of Massachusetts, the writer desires to express his deep obligations for many favors received.

FREDERICK J. H. MERRILL

Albany, Sept. 1, 1897

INTRODUCTION

Good Roads in New York

The present condition of the highways of New York is about the same as that of the roads of England at the beginning of this century, when they were so bad and the toll rates were so high that the subject of their improvement forced itself upon the attention of the British public. From the investigations which ensued under the supervision of prominent engineers, certain rules for road building were formulated, the adoption of which led to the construction of the fine highways for which Great Britain has so long been famous.

At that time there were no railroads in England and all produce was transported by wagon or canal so that the subject of road improvement was one of great commercial importance. The necessities of the occasion brought to the front in Great Britain many road engineers, most prominent among whom were Macadam and Telford, advocates of two different systems of road building, which are now used variably, according to the nature of the ground where the road is to be built. Road building under state supervision has long been a feature of European government and the time has now come when it must be recognized as a necessary function of government in the United States.

The important reasons for road improvement throughout our country are three: 1st the desirability of reducing the cost of hauling; 2nd the importance of making most of our roads fit fór pleasure driving, thereby attracting to the rural districts in summer, thousands of people who create a local market for various farm products; 3rd the economic principle of preventing the great waste of labor which is now fruitlessly expended in making bad roads.

The state of Massachusetts, which in our own country leads in systematic road building, has a highly organized highway commission, which has been at work since 1894. Under the direction of this commission the important highways of the state have been measured on the new topographic map and their total length determined to be 20,500 miles, exclusive of minor cross roads. The commission has projected the construction of a network of state roads amounting to 10 % of the whole, connecting the more important points throughout the state. At

different points on this projected network the commission has constructed, by request of local authorities, short pieces of road a mile or more in length, according to the most approved methods of road building, to serve as object lessons and create by the experience of their high quality a public demand for farther construction. These short pieces are extended from year to year to carry out the general plan.

Through the courtesy of the commission I am enabled to make a statement of the appropriations and expenditures from 1894 to the present time. I quote the following from a letter written to me by Mr. A. B. Fletcher, secretary:

"In 1894 and 1895, 86.37 miles of road were laid out. These roads cost on an average, for actual construction expenses, about $9,612. per mile, and the engineering and inspection charged to them was $1,130. per mile, making a total of $10,742. the average cost of the roads per mile, exclusive of office expenses and salaries of the commission and clerks.

"In 1896 39.8 miles of road were laid out. These roads not being complete in all cases, the cost shown is to some extent an estimate. It is estimated that these roads will average about $7,900 per mile for the actual construction, and $741 for the engineering and inspection, a total of $8,641 per mile."

The appropriations for the use of the commission have been as follows:

1894	$300,000
1895	400,000
1896	600,000
1897	800,000
Total	$2,100,000

From this it will be seen that with three years of careful work, Massachusetts has built 126 miles of good road in different parts of the state to serve as object lessons to the people.

As this official statement shows, in 1896, with an appropriation of $600,000, Massachusetts constructed forty miles of high class road. Since the appropriation for 1897 is $800,000, it may be assumed that a much larger mileage will be completed. As a certain proportion of the money appropriated is used for official and clerical salaries and expenses, the whole of the appropriation is not available for road building alone, but assuming the number of miles to be constructed in 1897 at 80, it appears that the total mileage to be rebuilt (2,000) would be completed at this rate in 25 years. It will be seen that the plan of road improvement now adopted in Massachusetts, is not intended to provide for any general improvement in the 18,500 miles of public highway not included in the system to be rebuilt by the state, except through the influence of the object lessons furnished in the local examples of new state roads.

The Problem of Road Improvement in New York

It being generally conceded that better roads are a necessity in New York and there being no economical way of obtaining good roads except by building the best, the question arises as to the source of the money necessary to do this work.

High class roads, if not built by the state, can at present be afforded only in regions inhabited by persons of more wealth than the average farmer. Near the large cities are great areas tenanted by those who have business in the city, but prefer to live in the country. There the property values are much higher than in regions exclusively devoted to agricultural interests and the taxes being proportionately higher, it is possible to spend more money in road building. Under the present system of road tax prevalent over the greater part of the state, the equivalent of about $75 a mile per annum is supposed to be raised in each road district outside of the village corporation limits, and it frequently happens that the whole of the tax is not worked out. Moreover, in many districts the people work their road taxes without intelligent supervision and often not only is the labor wasted but the roads are made worse.

The state of New York having an area six times as great as that of Massachusetts, has probably six times as many miles of important roads; there being as yet no complete map of our state, it is impossible to make accurate measurement. The total mileage of important roads in New York may therefore be estimated at 123,000. This figure, while only an approximate maximum, is sufficiently accurate for purposes of estimate.

If it were decided to improve 10% of this total according to the Massachusetts plan, there would be 12,300 miles of road to build. While Massachusetts now appropriates $800,000 a year for road building, New York, if doing this work at the same rate in proportion to her size, would appropriate $4,800,000 a year. This sum would be more than one third of the total amount raised in New York by direct taxation, which is now in round numbers $12,033,651.80. This is undoubtedly too large a burden to be carried, but we could safely afford to spend from $600,000 to $1,000,000 per year in this work, which can not be avoided and must sooner or later be undertaken.

In senate bill no. 330 of 1897 introduced by Hon. Richard Higbie, it was proposed to levy 'in the general appropriation act of each year, a tax rated at one tenth of a mill upon the entire valuation of the state, which shall be known as the state highway tax.'

The total value of taxable property for the current year is stated by the comptroller to be $4,506,985,694. This sum when taxed at the rate of one tenth of a mill would yield an annual amount of $450,698.56 available for the construction of state highways. On this basis each taxpayer would contribute only 10 cents on each $1,000 of assessed valuation.

It is considered by many that the wiser method would be to divide the cost between the *state*, the *county* and the *locality benefited.*

The proportionate division suggested in senate bill no. 330 of 1897, is one half by the state and one half by the county; it being also provided that the amount paid by each county may be apportioned by the board of supervisors so that 35% of the cost shall be a general county charge and 15% a charge upon the town in which the improved highway is located, or to be assessed upon and paid by the owners of the lands benefited, according as the request for the improvement comes from the board of supervisors of the county or from the owners of one third the lineal feet frontage.

As it is to be expected that the cost of road building in New York would be about the same as in Massachusetts, viz, $10,000 per mile, the cost of rebuilding at state expense the great system of public highways mentioned above would be about $123,000,000.

If so large a sum as $4,800,000 a year were appropriated and it were found possible with this sum to build 480 miles of road per year, a period of 25.6 years must elapse before the completion of the work. On the other hand, if New York were to appropriate exactly the same amount as Massachusetts, viz, $800,000 per year and could build 80 miles per year, it would require 153.7^5 years to complete the system of 12,300 miles. During all of this time and for all time to come *there would remain in New York a vast network of 110,700 miles of road inadequately cared for, as at present, unless some plan for intelligent supervision and repair were provided in addition to that for the work of constructing state highways.*

The apparent difficulty of enacting legislation involving a work of such great expense and covering so long a period of time leads to the belief that the solution of the road problem in New York is to be found in the division of the expense of state road construction between the state, the county and the locality benefited as already mentioned. Even this would not be a rapid process; allowing $1,000,000 for the construction of 100 miles of road per year, 123 years would be required for the completion of the undertaking.

The foregoing statements of expense and time are not made as arguments against state roads, but to call attention to the magnitude of the project and the fact that the work must be carefully planned. It does not seem necessary that the facts should be concealed from the public in order that the work may be undertaken. It should not be assumed that the work can be started only by concealing the total cost.

The legislation hitherto proposed has chiefly aimed at a few state roads. This is insufficient. We need a trained supervision over all public roads.

In order to meet these requirements it is most important that a bureau or commission of road improvement be created by the state with, at first, a small appropriation for the practical study of the road problem in New York, and the development of plans for the building of state highways and the working of all other roads under trained supervision. If our next legislature, as all good citizens must hope, shall decide to create a commission or bureau of state highways or a superintendent of highways *the measures then enacted should provide not only for the formation of a plan to build certain state roads* which shall be models of engineering work *but for the intelligent supervision of the general repair work done on the other roads of the state* during the centuries which must elapse before our main roads are put in proper condition.

A bill was introduced into the legislature of 1897 to compel the payment of all road taxes in money. While this is a most important measure which should be made a law, it is insufficient as it provides no supervision over the manner in which the money is to be spent. According to the observation of the writer, there are large areas in New York where the people do not know how to spend their road taxes to advantage, and where the tax if actually paid in money would still be wasted, unless some trained supervision were provided by statute.

Not every civil engineer is competent to superintend road work, not every farmer is ignorant of road making; but it frequently happens that commissioners of highways have not the necessary experience and training to fit them for their office; and, serving without salary, they can not afford to give the necessary time to the road districts under their supervision. It seems indispensable that apart from and in addition to any system for the building of state highways, there should always be a corps of trained inspectors, men of experience and capacity in road building, selected solely for their qualifications and under the direction of a central bureau or commission, who would in each county, town and road district supervise the work on roads not yet being rebuilt under state super-

vision, in order that the road taxes may be economically and efficiently spent. Such inspectors must necessarily receive salaries commensurate with their qualifications. These salaries should be paid in part by the state to insure central control and the adoption of uniform standards and in part by the counties where the inspectors are stationed in order to lessen the general burden of taxation.

The League of American Wheelmen is doing much in New York to arouse public opinion in favor of good roads. It is to be hoped, however, that this influential organization will not confine its attention to state roads alone but will advocate some measure to improve the general system of road supervision and repair.

It has been suggested that a part of the excise revenue under the Raines law might be used for building roads. This practical question must be decided by the people and their representatives in the legislature.

Natural Roads

In the United States most roads have natural beds and the character of these beds is determined by the geology of the region in which they lie.

Hence the road beds consist of clay, sand, loam or gravel, or occasionally are on the surface of the country rock which may be shale, sandstone, limestone, etc.

From the fact that an unfertile soil is not good for road building, it usually happens that the poorest roads are in regions of poor farms where property values and consequently taxes are low and there is little money to spend on the roads. This is especially true in stony districts, for a stony soil is a most unmanageable material for a natural road.

Of the natural roads those on clay soil are best in dry weather, those on sand best in wet weather. When wet with a certain proportion of water, fine sand becomes hard and elastic as we see on the beaches of our Atlantic coast, where good natural roads are found near the water's edge.

Of the natural soils the best for road purposes are those variable mixtures of sand and clay called loams. Loam roads average better through the year than those of clay or sand. A limestone gravel makes a very good road, and also a fine quartz gravel mixed with clay.

From every-day experience, it is clear that natural road beds are not the best for heavy traffic when under varying conditions of moisture. It

is also clear that for many centuries to come, large areas of our country can hope for nothing better than good natural roads.

The faults of our natural roads which could easily be remedied are mainly these:

1 The roads are too narrow and too high in the center, and on account of their narrowness the wheels all run in the same track and the extreme curvature of the road bed compels the wheels to run on the edge instead of the surface of the tires, the combination of the two faults causing the formation of deep ruts;

2 Loose stones are allowed to remain in the roads and the work of repair is not directed toward keeping the surface smooth;

3 Insufficient attention is given to the construction of drains and culverts.

Road Construction

The experience of over 2,000 years has shown conclusively that there are two essential points to be aimed at in the construction of a perfect road;

1 A hard, smooth, waterproof surface;

2 A thoroughly dry foundation.

These principles were known to the Romans three hundred years before Christ and used in the construction of their best highways.

The surface of a good road must be of sufficient strength to resist the wear and tear of traffic, and smooth enough to prevent undue strain and wear on vehicles. In connection with this *the soil beneath must be made dry and kept dry.* Therefore the subject of road drainage is as important as that of road metalling.

The best road covering is composed of angular fragments of some stone which will grind on the surface into a dust, which when wet will bind or in a measure cement the fragments together, so that water will not penetrate. The angular form is essential to make the fragments interlock. The sizes should be quite uniform, except that the surface layer may consist of fragments different in size from those in the bottom course.

The total thickness of this metalling must be at least six inches on a natural soil foundation. The fragments should not exceed two and a half inches in diameter, and should be rolled in two separate courses with a heavy steam roller until the surface is absolutely firm. This is the Macadam system.

Where the soil foundation is clay, or for any reason difficult to drain, the Telford method is used. In this case a course of flat stones about six inches deep, set on edge and closely wedged together, is placed upon the soil and crushed stone is placed over this four inches thick and rolled solid. In good practice it is customary to roll the earth before the stone is laid upon it and then roll the stone foundation. The Telford foundation forms a bridge which prevents the road from sinking in moist soil and is rendered completely effective by tile drains on each side of the road. *After the road is built it must be kept constantly in repair and the neglect of this principle is to a great extent responsible for the poor roads of the United States.*

The Macadam and Telford systems above described are necessary for roads designed for heavy traffic in all weathers, but roads for pleasure driving in summer only, do not need the same expensive preparation.

As an example of the methods adopted for the construction of high class roads I am permitted by the courtesy of the Massachusetts Highway Commission to quote the following extracts from its pamphlet of *Instructions to engineers*, published in 1896:

Gravel. You will use gravel for surfacing the road bed under telford; also for surfacing the sub-grade where the natural soil is clayey, loamy, or where ordered under other conditions by the chief engineer. The gravel must be practically free from sand and clay.

Broken stone. State highways are divided as follows with reference to the broken stone (sizes given are in inches):

1 All trap rock, 1 bottom 1st course to be 1¼ to 2½; top course to be ½ to 1¼;

2 All trap rock, both courses to be 1¼ to 2½;

3 Local stone other than trap, bottom course to be 1¼ to 2½; top course to be ½ to 1¼;

4 Local stone other than trap, both courses to be ½ to 2½;

5 Bottom course of local stone other than trap, ½ to 2½; top course of trap rock, ½ to 1¼;

6 Bottom course of local stone other than trap, ½ to 2½; top course of trap rock, 1¼ to 2½;

7 All trap rock, bottom course to be ½ to 1¼; top course to be 1¼ to 2½;

8 Local stone other than trap, bottom course to be ½ to 2½; top course to be 1¼ to 2½.

When 'local stone other than trap' is used you must not allow any soft or disintegrated rock to go upon the road; all such rock must be rejected before breaking. If the contractor fails to remove such rock, immediately report the fact in writing to the chief engineer.

All broken stone must be screened, and any broken stone which will not pass through a 2½ inch ring, or is more than 2½ inches in its largest diameter, must be rebroken or rejected.

In every case the screenings used on the surface as a binder course must be of the same kind of stone as the top course of the road.

Rolling. When possible roll the sub-grade with a steam roller.

If the sub-grade is too sandy to roll, cover with coarse gravel laid on to a depth of 3 inches, or as much more as may be needed to give a good foundation.

Fill any depressions with the same material until the surface is true and even.

All broken stone must be rolled in screened layers.

After spreading the first course of broken stone, begin rolling at the sides, and continue this by running ahead so as to allow from 2 to 5 inches of the driving wheel to pass over the shoulder, and backward with the outer edge of the driving wheel from 5 to 10 inches inside the edge of the broken stone. Roll until the stone ceases to 'wave' in front of the wheels, and until it seems firm under foot as you walk over it. Next begin on the other side and roll in the same manner. Then work toward the center until the stone is rolled. Roll each layer of stone in the same manner.

If the road shows a wavy motion after passing the roller over it three, four or more times, it may indicate too much moisture in the sub-grade. If, on examination, you find this to be true, stop rolling and move ahead, allowing time for the sub-grade to dry out.

With some coarse, hard granitic rocks it has been noted that after the roller passes over them a few times they begin to 'crawl' and the sharp edges break off. A slight sprinkling of sand or stone screenings, or water, may prevent this. Try one after another of these means, until the work progresses to your satisfaction. You must not expect to prevent the stone from shaking as you walk over it, but you need to continue the rolling until the fragments of stone adjacent to where the foot presses do not move as you walk. Most of the rolling must be done before you spread the screenings. After spreading the screenings, water and roll until the mud flushes to the surface. You can not expect to prevent the stone from kicking out if the teams pass over the road. Keep watch, and in a few days have the roller pass once or twice over the road, after watering, until the loose stones are pressed down out of sight.

Before spreading any broken stone, great care must be taken to have the sub-grade carefully shaped and thoroughly compacted.

All shoulders must be shaped and left sufficiently high to roll to the proper grade, before any broken stone is spread on the road.

In case of heavy fills you must not run the roller to the edge of the shoulders unless the fill has had time to settle. Work out slowly on this kind of work.

In every case the screenings used on the surface as a binder course must be of the same material as the top course of the road.

Excepting where it may be needed to compact hard, granitic rocks, as before referred to, you will use water only on the top, or binder course.

You will wet this binder course thoroughly before rolling, but not to the extent of saturating the foundation. You will get better results and

prevent the screenings from being picked up by the wheels of the roller if you apply the water and allow it to settle down below the top surface before passing the roller over it. Too much water, or too little, will give trouble by causing the surface to be picked up.

You must not under any conditions roll the screenings while dry.

You must not under any conditions allow teams to pass over the road after the screenings are spread and before they are rolled.

In case of a deficiency in the water supply, you may have the screenings spread and await a rain before rolling; but in such case the road must be entirely closed to travel, and the rolling must be begun as soon as the road is wet and continue until the section covered with screenings is thoroughly compacted. In such cases it may be necessary to operate the roller day and night, and you must insist on this being done. In case you meet with any difficulty in compacting the stone, and fail to understand the cause, report immediately in writing to the office.

Telford. Telfording will be used in all cases where the road passes over clay, or wet soil. You will make a careful study of the road, and report in writing to the chief engineer where in your opinion telfording is needed, giving a description of the soil, together with the general scope of the adjacent ground. In your report you will note the stations between which the telfording may be needed.

Where telford is to be used, you will see that the road bed is excavated and carefully rolled, and left true and even, corresponding to the cross-section, and 12 inches below the established grade of the finished work. You will then cause 2 inches of gravel to be uniformly spread over the sub-grade. On this sub grade you will place a foundation of stones, which may vary in size as follows: 4 to 10 inches in width, 6 to 20 inches in length, 5 to 6 inches in depth (not more than 10% of the stone to be less than 6 inches in depth). The stone must be sound, and of a quality approved by the chief engineer.

The telford stones shall be placed by hand, vertically, on the broadest edges and lengthwise across the road, so as to form a close, firm pavement. They shall be bound by inserting and driving down, in all places where it is practicable, stone of proper size and shape to wedge them in their proper position. No large stone will be left with a projecting point coming nearer than 4 inches to the finished grade and cross-section. If any such projection be found, it must be broken off to allow a clear depth of 4 inches of broken stone.

The telfording shall then be rolled with a steam roller, all depressions filled with stone chips or spalls, rolled and left true and even and 4 inches below the finished grade and cross-section. If a drain is to be put in, it must be finished after the excavation is made and before the gravel is spread.

Drains. Where telfording is used, or where ground water from a side hill may work injury to the road, you will build drains.

If the road passes through a cut, you will place a drain on each side.

If the road is on a side hill, you will place a drain on the up-hill side only.

All drains must be carried to a proper outlet, either to a culvert, to another drain or through the bank.

Where it is necessary to extend a drain to an outlet beyond the section needed to be drained, you will lay the pipe with cement joints on such extension, and omit the gravel or stone in the trench.

Where a pipe is carried through a bank, the outlet must be protected by masonry, as provided in pipe culverts.

All pipe must be laid true to the line and grade, and no pipe is to be laid on a grade of less than 3 inches in 100 feet.

If in laying out a drain you find the trench is likely to exceed 5 feet in depth below the finished grade, you will immediately report the conditions in writing to the chief engineer.

The center of the pipe in all drains will be placed 12 inches outside of the line of broken stone.

When the grade of the finished road is 3 inches or more to the 100 feet, the bottom of the drain trench must be 3½ feet below the finished surface of the road at that part of the cross-section.

The drain trench will be excavated to a width of 12 inches at the bottom and 15 inches at the top, and should be excavated only as fast as the drain can be finished.

On the bottom of this trench you will place 2 inches of gravel or broken stone which will pass through a 1¼ inch mesh and not through a half inch mesh.

All side drain pipe will be 5 inches salt-glazed vitrified clay pipe, with bell and spigot joint (unless stated to the contrary in the specification).

The pipe is to be laid on the grade hereinbefore mentioned, with open joints and the bell end toward the rising grade.

Gravel or broken stone of the sizes already described will be filled about the pipe and over it for a depth of 5 feet. This must be carefully tamped about and rammed over the pipe. The remainder of the trench is to be filled with stone which will pass through a 3 inch and not through a 1 inch mesh. Great care must be taken to prevent any sand, silt or earth from getting into the pipe or the interstices of the stone in the trench.

The sub-grade of the road is to have a regular slope to the edge of the drain.

Gutters. Paved gutters will be built where directed by the chief engineer.

No gutter is to be laid until after the broken stone has been rolled.

In no case is the roller to pass over any part of any paved gutter.

Gutters not exceeding 400 feet in length shall be 3 feet wide with a shoulder 1 foot wide and a dish of 3 inches.

Gutters exceeding 400 feet in length shall increase the dish above this length at the rate of 1 inch to each 300 feet.

All stone used in gutters shall be rounded field, bank or river stone; no flat, shaky or rotten stone shall be used.

The stone may on the average lay from 4 to 6 square yards to the ton. A cubic yard may be estimated to weigh 1⅓ tons.

The larger selected stone will be laid in the gutter itself and on the edges to a true line and grade, with the largest diameters lengthwise of the road. All other stone will be laid with the longest diameters across the gutter.

The trench shall be excavated to a depth of 12 inches below the finished grade of the gutter; gravel shall then be spread and rammed to a depth of 4 inches. A layer of bedding sand or gravel free from stone larger than ½ inch in diameter shall then be spread of a sufficient thickness to bring the gutter stones which are bedded in it to the proper grade and cross-section after they are thoroughly rammed.

Each stone is to be rammed to an unyielding foundation. The surface shall then be covered with sand or screened gravel, which must be well broomed into all joints. The stone shall then be re-rammed and the surface left true and even. Sand or screened gravel shall then be spread over the entire surface of sufficient depth to fill all interstices.

The edge of the gutter toward the road shall be left ¼ inch below the surface of the adjoining broken stone; in no case must it project above it.

Any broken stone which may be disturbed during the paving of the gutter must be carefully replaced and thoroughly rammed.

The bank on the outside of the gutter must be sloped to the gutter, so as to have no bunches or depressions on its surface.

These extracts show the careful attention paid to small details of construction, in the state highway work of Massachusetts.

Earth Roads, Construction and Maintenance

It is not proposed, within the limits of this article, to go into further detail on the subject of road building, as there are already many books in which this subject is adequately treated, especially the construction of Macadam and Telford roads. It seems important however, to call attention to some of the difficulties encountered in maintaining earth roads. If there were no rainfall it would be comparatively easy to make and maintain roads of clay, loam or gravel. Rain, snow and frost are the chief sources of trouble. *Theoretically* by a curved cross-section of road bed the water is caused to flow off, *practically* as soon as the road bed is softened by rain, wheel tracks quickly form longitudinally and prevent the water from escaping except at long intervals. It therefore is of little value to give an earth road a cross-section of pronounced curvature. The nearer flat it is without approaching concavity the wider the bearing of the wheels on the road bed and the less the cutting by them. A slight convexity is desirable to balance the wear along the central line.

In hilly districts where grades are steep, it is of the greatest importance to prevent the water from flowing lengthwise of the road. This is effected inexpensively by making a ridge of earth across the road which turns the water to one side or the other. These ridges, which are called breaks or breakers and in some localities 'thank you ma'ams,' are uncomfortable to drive over and have little durability. On very steep ascents

these breaks are of use in supporting heavily laden wagons while the teams are resting.

The practice of chaining a wheel in descending a steep hill with a loaded wagon, which method provides an inexpensive substitute for a brake, rapidly wears deep ruts in hill roads and in the 'breakers' built across them. This practice is far more destructive than the use of narrow tires and should be prohibited by law as soon as possible. On hill roads where the ascent is not too steep to permit the maximum load to be drawn continuously so that it is not necessary for the team to stop and rest, a very satisfactory substitute for 'breakers' is found in a wooden box drain or sluice placed across the road at a slight angle with the perpendicular, the top consisting of oak slats about 3 in. x 4 in. with a space of about 2 in. between them. These transverse gratings intercept and carry off the water flowing lengthwise of the road, which if allowed to go far would gain in volume and erosive power until serious damage would be done.

A part of the work of the Massachusetts Highway Commission has been to eliminate steep grades from the roads built at state expense. In many cases a change of location has been found necessary to accomplish this end.

A serious cause of wear on roads is the filling of the gutters with snow and ice which often accumulates to such a height as to make the center of the road the principal line of drainage. When this occurs on earth roads, in early spring a large volume of snow-water follows this channel, seriously damaging the road and necessitating much expense in its repair. Even the best type of Macadam or Telford road would eventually be damaged in this way. I am informed by the Massachusetts Highway Commission that it has been found necessary in that State to have the snow removed from the gutters in order to prevent damage of this character. When the gutters are open it is not a difficult matter to remove the snow and ice if sufficient money is provided for the purpose. It is however, the custom in our rural districts to have gutter bridges and box or stone drains at the junction of private roads or minor cross roads with the main highways. When these become clogged with ice as they invariably do, it is impossible to clear them without taking them apart and this is rarely practicable.

In Massachusetts these gutter bridges are prohibited on the new roads, the lateral roads being made to meet the main roads at a very gentle slope, leaving an open gutter which may be driven over without discomfort. With an earth road it would be difficult to maintain such an open

gutter at road intersections unless some person were detailed to keep it in continuous repair. As this has not yet been found practicable on public roads, the gutter bridge is everywhere in use, and in the spring it is a fruitful source of injury to the road. It will be seen from every day observation and from the details stated above that the earth road while as yet all that the people have agreed to have in New York has necessarily many elements of self-destruction and can never be regarded as permanent. The development of the wheel scraper or road machine has made it possible however to keep an earth road in good condition if intelligently used.

For speedways and pleasure driving in general, a well kept earth road in dry weather is superior to all others. The perfect Macadam or Telford road is too hard to permit of very fast driving without injury to the feet of horses.

Road Materials and their Distribution

In New York the best materials for road metal are trap, granite and magnesian limestone.

Trap is a general term for some of the basic eruptive rocks, the word being related to or derived from the German *Treppen* which signifies a flight of steps and is suggested by the somewhat regular manner in which the rock is jointed.

The trap which is used in New York for a road metal is a diabase and consists chiefly of the minerals augite and labradorite, the former being a silicate of iron and magnesia and the latter being a lime-soda feldspar. Other minerals are present in small quantity but do not influence the properties which make the rock valuable as a road metal.

While sufficiently hard to resist the wear of heavy traffic to a satisfactory extent it possesses a high degree of binding or cementing power. This means that the dust produced by wear when moistened unites quite firmly and forms a cement which binds the larger fragments to a considerable extent.

This property is most noticeable in rocks containing much lime, magnesia and alumina.

Good trap is known only in Richmond and Rockland counties, and in the intermediate area of New Jersey bordering the Hudson river. Its very prominent outcrop is known as the 'Palisades.'

Granite consists chiefly of quartz mixed with one or more of the feldspars and hornblende or a mica. Hornblende has essentially the same composition as augite which occurs in trap; and a hornblende granite should be a

very good road metal. Where hornblende is absent one would expect to find less binding power.

Granite is harder than trap and therefore should resist wear better, but this quality is offset by its usually smaller binding power due to the presence of quartz so that trap should be preferred as a rule.

Granite is found in the Adirondack region and in the Highlands of the Hudson, also in Westchester county. The commercial term granite includes various kinds of gneiss.

Magnesian limestone has great binding power but is quite soft and therefore not very durable for heavy traffic. Chemically, this rock is chiefly a carbonate of lime also containing carbonate of magnesia, alumina and silica. Limestone entirely free from magnesia is rare.

It has been suggested that this stone may be used profitably as a binder over stone of less binding power.

Limestone is found chiefly in areas parallel to and near the main line of the New York Central railroad and in a zone around the Adirondacks.

Sandstone consists chiefly of quartz, has usually no lime, magnesia or alumina and therefore has no binding properties and never makes a first rate road, as the fragments continually break loose.

In New York the best road materials occur in certain limited areas, and at points distant from these the cost of transportation is the controlling feature in the question of their use.

The accompanying map shows the distribution of the areas of rock already mentioned which are available for road construction in New York.

For high class road building, trap and granite will be preferred and used in all places where their cost is not prohibitory. Experience shows, however, that unless these materials are used under the direction of experienced road engineers, they are less satisfactory than limestone, and when it is proposed to macadamize a road by simply covering it with broken stone, the latter though less durable, will be more satisfactory.

When granite and trap are properly laid, on a well prepared bed and rolled with a heavy steam roller to the proper standard of firmness, nothing can be better, but where no steam roller is available and the subgrade is not properly prepared, the trap and granite are liable to afford only an unpleasant and uneven surface of hard angular fragments which ceaselessly roll about on the surface of the road injuring the horses and making pleasure driving impossible.

Limestone from its softness and greater binding power is more easily rolled into an even surface under the wheels of vehicles, and while not

having the durability to support heavy traffic for a long time, can be cheaply renewed if the source of supply is not far distant. This fact has been recognized for a long time at points within easy reach of the limestone quarries. In Onondaga county at many points a portable crusher has been used to crush for road metal the blocks from the limestone fences which are cheerfully donated by the residents for the improvement of the roads. There are many other counties in which this might be done as may be seen from the map which shows the distribution of the limestone areas. In most of these areas limestone will be found in the fences and may be crushed for road metal at small expense.

The lists of quarrymen and the maps at the end of this bulletin explain the distribution of materials available for road building.

The distribution of road materials may also be studied in greater detail on the Economic Map of New York by F. J. H. Merrill which shows both the geology and the mineral deposits on a scale of 12 miles to 1 inch and on the Preliminary Geologic Map of New York by the State Geologist which shows the geology on a scale of 5 miles to 1 inch ‡

In addition to the outcrops and ledges where quarries may be opened the deposits of boulders and gravel whrch we call glacial drift often yield good materials for road metal at a long distance from the original source. These deposits cannot as yet be mapped but they are usually well known in the regions where they occur.

Tests of Road Material

The most practical test of road metal is actual use, and this has been the principal guide in the past; but as the demand becomes greater for new localities of road metal in order to reduce transportation charges, it has become necessary to devise physical tests which may be used in the examination of new materials offered for road building.

The following description quoted from the report of the Massachusetts Highway Commission for 1896, describes in detail the methods in use by that organization.* †

LABORATORY EXPERIMENTS ON ROADBUILDING STONES

The following described results were obtained in the highway laboratory of the engineering department of the Lawrence Scientific School of Harvard University. Those under the head 'Coefficient of abrasion' were obtained by the Deval method, which has been employed for some time by the French engineers for determining the relative value of the

* Pp. 86–91. † In this quotation, metric weights and measures have been reduced to common forms.
‡ For Westchester Co. see A Geological Map of a Part of Southeastern New York by F. J. H. Merrill, in Bulletin 15, N. Y. State Museum; also in 48th Ann. Rept. N. Y. State Museum.

stone used in the construction and maintenance of the national highways of France. These results are said to agree well with those obtained in actual practice.

The apparatus used in the tests consists of a cast-iron cylinder 8 in. in diameter and 13.6 in. in depth. At one end is an opening which can be closed with a tightly fitting iron cover. This cylinder is mounted on an axle at an angle of 30° with the axis of the cylinder, and is supported on an iron frame. At one end of the axle is a pulley wheel by which the cylinder is revolved; at the other is an instrument which records its revolution.

The stone to be tested is first broken into pieces, between 2½ in. and 1¼ in. in diameter, which are carefully washed, to remove any foreign matter. In the cylinder are placed 5 kilograms (13⅓lbs.) of this stone. The top is then bolted on, and the cylinder is made to revolve for 5 hours at the rate of 2,000 revolutions an hour, making in all 10,000 revolutions. By this process the stones are thrown from one end of the cylinder to the other, and at the same time are rolled against the sides of the vessel and against one another. When 10,000 revolutions are completed, the cover is removed, and the contents emptied into a tray. The cylinder is then thoroughly washed, to remove the dust that adheres to its sides. Each stone above 1¼ in. in diameter is then washed under the same water. This water is then filtered, and the filtrate when dry is mixed with the detritus taken from the cylinder. The detritus is then put into a sieve, by which it is separated automatically into seven sizes. These seven sizes, together with the stones that have not been worn below 3.18 cm. in diameter, are each carefully weighed, and their weights recorded.

The amount of detrition under 1-16 in. is rarely less than 20 grams per kilogram of stone used (2 %) therefore 20 has been adopted as the standard, and the coefficient of quality is obtained by the following formula:

$$q = 20 \times \frac{20}{u} = \frac{400}{u} \quad u = \text{per cent}$$

in which u represents the weight in grams (15.43 grs) of detritus per kilogram (2 2-3 lbs) of stone.

It seemed well, in beginning this work, to be guided as far as possible by the experience of others, and for this reason the Deval test was adopted, for it appeared to be the only practical method of testing road metals yet devised. After a number of trials were completed with the Deval apparatus, and their results studied, it was recognized that all the valuable properties possessed by a good road metal were not embraced in this test. The value of any good stone as a road metal is due to certain properties possessed by it. Among these there are three which stand prominent — cementing value, toughness and hardness. It is evident that the Deval apparatus does not test the very important property of cementing value in the different road metals. The commission, recognizing this deficiency, accordingly directed its attention to devising some means of supplying it. As no previous attempt has been made in this direction, the commission had to invent its own method, which is as follows:

The stone to be tested is ground to a powder, and passed through a sieve of 100 meshes to 1 m. The powder is then put in a slightly tap-

ered steel die of circular section, about 1 1/4 in. diameter, mixed with water, and subjected to a pressure of 2,300 kilograms (about 3 tons). The resulting briquette is then put aside for at least one week, so that it may thoroughly dry.

It was at first thought that a test by direct compression would determine the cementing power of the stone. A number of briquettes were tried in this way, but the results were not very satisfactory. On further consideration, it appears that a test by impact would more thoroughly determine the cementing power of the stone then that by compression, and this method would have the further advantage of approximating more closely to the actual conditions obtaining on roads; accordingly a machine was devised for testing the briquettes by impact. With this machine a hammer one kilogram (2 2-3 lbs) in weight can be dropped freely from any desired height upon a plunger under which the briquette to be tested is placed. The hammer works automatically and is tripped at the desired height. Attached to the plunger is a lever, pivoted at one sixth of its length from the plunger, and carrying a pencil at its free end. The pencil has a vertical movement five times as great as that of the plunger, and its movement is registered on a drum against which the pencil presses. The drum rotates through a small angle at each stroke of the hammer. An automatic diagram is thus taken of the behavior of the briquette throughout the whole test.

An analysis of the diagram so taken shows at once the number of blows required to cause the destruction of the briquette. A very interesting point is brought out by these diagrams, viz, in every case the diagram shows that the plunger rebounded at each stroke until the briquette began to fail. This behavior is exactly analogous to the elastic phenomena observed in all material of construction; consequently the point at which the briquette ceases to rebound corresponds to the elastic limit of the material. Beyond this point the briquette falls to pieces rapidly.

Briquettes were made from many kinds of stone, and were tested in this machine. It was thought desirable to use a constant blow for all the briquettes, and a short experience indicated a fall of 1 1/4 in. as suitable, since it broke the most tenacious materials with a moderate number of blows, and yet was not too great to permit the careful determination of the properties of the poorer stones. All the briquettes were 1 in. high.

The surface of a macadamized road is constantly being abraded and recemented. Evidently a road made from a material which has the property of recementing in a high degree will keep in better condition than one made from a material of lower recementing power. It was therefore desirable to determine the recementing properties of the stones tested. A new set of briquettes was made, differing from the former only in that they were of constant weight instead of constant height. These were tested in the manner described above, and then were remade and retested.

It has not been thought desirable to present herewith the complete data obtained from the impact test: as the series is not yet completed. The writer has, however, collected and shown in the accompanying table some of the more important results thus far obtained, a sufficient number to indicate the scope of the work done. In this table the stones are arranged in the order of their power of resisting abrasion. Column 1

contains the specific density of the stones; column 2, the coefficients of abrasion (determined in the manner previously described); the next column gives the number of blows required to stress the 1 in. briquettes to their elastic limits; column 4 gives the same data for the first testing of the 30 gram (463 [illegible]) briquettes prepared for the recementation test, and the next column gives the number of blows that the recemented briquettes will stand before reaching their elastic limits."

Through the courtesy of the commission six specimens of typical New York rocks were subjected to the abrasion test with results which are noted in the following table; which also gives the results of some tests of Massachusetts rocks.

Table showing specific densities, coefficients, cementing values and recementing values of stones tested

NAME OF STONE	City or town	1 Specific density	2 Coefficient of wear	3 Cementing value	4 Cementing value of 30 gram briquette	5 Recementing value of 30 gram briquette
**Massachusetts*	*rocks*					
Diabase	Lynn, Essex co., Mass	3 03	20 37	....	56	29
Felsite	Boston, Suffolk co., Mass	....	16 06	23	109	31
Hornblende granitite	Duxbury, Plymouth	2 68	13 46	....	....	....
" "	Waltham, Middlesex co., Mass	2 62	12 16	16	....	....
Gneiss	Lee, Berkshire co., Mass	....	11 43	23	....	....
Limestone	Pittsfield, Berkshire co., Mass	2 82	9 38	15	....	....
Quartzite	Diamond Hill, Cumberland, R. I.	....	9 07	9	....	....
Marble	Lee, Berkshire co., Mass	2 74	2 85	....	....	....
†New York	*rocks*					
Diabase, Bouker	Guttenberg, N. J.	....	30 40	....	....	....
" Conklin & Foss	Rockland Lake, N. Y	....	17 79	....	....	....
Norite	Cortland, Westchester co	....	7 46	....	....	....
Granite, D. Donovan	Round Island, Rockland co	....	23 02	....	....	....
Silicious sandstone	Lockport, Niagara co	....	17 48	....	....	....
Sandstone	Duanesburg, Schenectady co	....	10 53	....	....	....
Limestone	Howes Cave, Schoharie co	....	9 64	....	....	....
"	Tomkins Cove, Rockland co	....	6 31	....	....	....

* From the Report of the Mass. Highway Com. 1896. † Tests made for the New York State Museum by the Mass. High. Com.

As shown by the preceding table, the New York rocks tested in the laboratory of the Massachusetts Highway Commission were only subjected to the abrasion test and therefore the results can not be fully compared with the tests of the Massachusetts rocks which are given above. Two samples of traps were tested, one from the Bouker quarry at Guttenburg and one from the quarry of Conklin & Foss at Rockland Lake. The specimen tested from the Bouker quarry proved to be very much harder than that from the Conklin & Foss quarry. There are two varieties of trap found in the Bouker quarry; one being considered of inferior quality and known by the quarrymen as "*false trap.*" It is part of the lower portion of the trap mass and being near the sandstone which forms its lower foundation, it cooled more rapidly and assumed a finer texture and a harder condition than the mass above. Although this so-called false trap has not been subjected to a cementation test, one would expect it to prove equally valuable with the rest in this respect, as its chemical composition is probably nearly identical with that of the softer trap immediately adjoining. It was a sample of the "false trap" which was tested.

It is stated that where used at some points on Long Island it has proven unsatisfactory, the fragments not holding together and forming an even surface, but frequently flying out.

The attention of the writer has been called to this fact, but he has not sufficient information to warrant a full expression of opinion. The difficulty may be due to improper construction in building the road. It might also be due to the mixture of this harder variety of trap and softer material from the same quarry, it being well established by experience that unless the road-metal in the surface layer is of uniform hardness, it will not wear uniformly. To establish the truth in this case would involve a good deal of experimental work for which no funds are available, but theorizing on the facts accessible, there seems no reason why the harder trap or false trap should not make a good road provided it is kept separate from material of different hardness and is laid under the supervision of a competent engineer.

As a rule when it is not possible to make numerous tests and experiments, it will be cheaper to use those materials which have proven satisfactory in actual use.

Owing to the press of state work it was not possible for the Massachusetts commission to make cementation tests of the specimens submitted. The tests made, confirm the results of practical experience and show that granite, trap and sandstone are harder and offer more resistance to abrasion than the limestones. The cementation test, when made, would unquestionably show the highest cementing value to be in the limestone, trap and granite and the lowest in the sandstone.

PRODUCERS OF ROAD-METAL IN NEW YORK STATE

Limestone

P. C. denotes that the stone is crushed in a public crusher owned or hired by the town or village. The number in the column headed *test* is the coefficient of abrasion as determined in the laboratory of the Massachusetts Highway Com.

NAME	Test	Town or village	County	
Allter Bros	......	St Johnsville	Montgomery	
Alvord, A. E.	......	Manlius	Onondaga	
Babcock, Dwight	......	Waterloo	Seneca	
Barber Asphalt Paving Co	......	Buffalo	Erie	
Behan's Estate, James	......	Manlius	Onondaga	
Bennett, J. & Son	......	Auburn	Cayuga	P. C.
Britton & Clark	......	Onondaga	Onondaga	
Brown & Fleming	......	Verplanck	Westchester	
Buffalo Cement Co	......	Buffalo	Erie	
Callanan Road Imp. Co	......	South Bethlehem	Albany	
Chaumont Co. (The)	......	Chaumont	Jefferson	
Chazy Marble Lime Co	......	Chazy	Clinton	
Conley, F. E	......	Oriskany	Oneida	
Driscoll Bros. & Co	......	Ithaca	Tompkins	
Dunlap & Co., R	......	Jamesville	Onondaga	P. C.
Foery & Kastner	......	Rochester	Monroe	
Hibbard, John P	......	East Onondaga	Onondaga	
Howard, John F	......	Ogdensburg	St Lawrence	P. C.
Howe's Cave Association	4.15	Howe's Cave	Schoharie	
Hudson River Stone Supply Co	......	Stoneco	Dutchess	
Jones, Hadley	......	Littlefalls	Herkimer	
Lauer & Hagaman	......	Rochester	Monroe	
Lynde, B. A	......	Bellevue	Erie	
Miller, Geo. W. & D. C	......	Newburgh	Orange	
Mohawk Valley Stone Co	......	Palatine Bridge	Montgomery	
Newark Lime & Cement Mfg. Co.	......	Rondout	Ulster	
Rausier, Huestis B	......	Manlius	Onondaga	
Roberts, R. W	......	Collinsville	Lewis	P. C.
Shute & Rightmyer	......	Hudson	Columbia	
Smith, W. T	......	Sharon Springs	Schoharie	
Snyder, C. G	......	Aquetuck	Albany	
Solvay Process Co	......	Onondaga	Onondaga	
Stainthorpe, C. N	......	Lockport	Niagara	
Tomkins Cove Stone Co	6.34	Tomkins Cove	Rockland	
Wagar, Isaac F	......	Milton	Saratoga	
Whitmore, Rauber & Vicinus	......	Rochester	Monroe	
Worlock, Cyrus	......	Perryville	Madison	

Granite

NAME	Test	Town or village	County	
Ausable Granite Co., B. B. Mason, agent	......	Keeseville*	Essex	P. C.
Bellew & Merritt Co	......	Tuckahoe	Westchester	
Donovan, Dan'l E	1.73	Round Island [a] town of Stony Point	Rockland	
Rampe Bros	......	Pine Island, town of Warwick	Orange	
Smith, Hay	......	Garrison	Putnam	
Thousand I. Granite Co	......	Grindstone Island town of Clayton	Jefferson	

* This rock is technically a *norite*

a Near Iona Island

Producers of Road-metal, Etc., concluded.

Trap

NAME	Test	Town or village	County
Bennett, Frank	......	Port Richmond	Richmond
Conklin & Foss	2.25	Rockland Lake	Rockland

New York firms having quarries in New Jersey

Bouker Contracting Co	1.31	Guttenberg	Hudson Co., N. J.
Carpenter Bros	......	Guttenberg	" N. J.
Lane, John S. & Son	......	Fort Lee	Bergen Co., N. J.

Sandstone

Albion Stone Co	......	Albion	Orleans
Conley, F. E	......	Higginsville	Oneida
Fowles, Joseph	......	Ithaca	Tompkins
Shear, Albert & Co	3.80	Duanesburg	Schenectady
Swett, A. L	......	Medina	Orleans
Whitmore, Chas	2.29	Lockport	Niagara

Directory of Quarrymen in New York State

Arranged in alphabetical order by post-office addresses

† Proprietors of quarries operating previous to 1897; now idle.
* Proprietors of quarries operating in 1897.
Parties not marked with dagger or asterisk have not been heard from directly, but are reported to be operating.
B. S. = Building stone

R. M. = Road metal
L. = Lime
C. = Cement
M. = Marble
P. C. = Public crusher

Granite

Post-office address	Name	Location of quarry: Town or village nearest to the quarry	Location of quarry: County	
Cold Spring	Bailey, C. W.*	Phillipstown	Putnam	B. S.
"	Bailey, James E.†	"	"	"
Garrison	Smith, Hay*	"	"	B. S. & R. M.
Gloversville	Edel, John*	Johnstown	Fulton,	B. S.
"	Wright, John	?	"	....
Goshen	Empire State Granite Co.*	Pine Island	Orange	B. S.
Keeseville	Ausable Granite Co. (B. B. Mason, agt.)*	Chesterfield	Essex	B. S. & R. M., P. C.
New York	Donovan, Daniel E.*	On Round Island, town of Stony Point	Rockland	B. S. & R. M.
Montreal	Thousand I. Granite Co.†	Thurso	Jefferson	B. S. & R. M.
Peekskill	Mohegan Granite Quarrying Co*	Cortland	Westchester	B. S.
Pine Island	Rampe Bros*	Warwick	Orange	B. S. & R. M.
Suffern	Rice Bros	Ramapo	Rockland	
Thurso	Kelly Granite Co*	Clayton	Jefferson	B. S.
"	Potter, O. L†	"	"	B. S.
"	White, Burgess & Co*	"	"	B. S.
Tuckahoe	Bellew & Merritt Co*	Tuckahoe	Westchester	B. S. & R. M.

Gneiss (Granite)

Croton Falls	Ganung, Edwin C †	Carmel	Putnam	B. S.
Hartsdale	Butler, C	Hartsdale	Westchester	B. S.
"	Dobbs, G. W	"	"	B. S.
"	Hitchcock, Welcome G	"	"	B. S.
"	Landers, J. H	"	"	B. S.
"	Wilson, J. C*	"	"	B. S.
Hastings	Nichols Henry *	Greenburg	"	B. S.
Littlefalls	Littlefalls and Dolgeville R. R.†	Littlefalls	Herkimer	R. M.
Scarsdale	Seely, Henry S †	"	"	B. S.
Tarrytown	Sackett, Stephen J. (estate)*	"	"	B. S.

Trap

Haverstraw	Conklin & Foss *	Rockland Lake	Rockland	R. M.
Port Richmond	Bennett, Frank*	Northfield	Richmond	R. M.

New Jersey quarries supplying New York

Guttenberg, N. J	Lane, John S. & Son *	Guttenberg	Hudson	R. M.
New York city	Bouker Contracting Co*	"	"	R. M.
Port Chester, N. Y	Carpenter Bros *	Fort Lee	Bergen	R. M.

Limestone

Accord	Bennett, John*	Rochester	Ulster	B. S.
"	Krom, George*	"	"	L.
"	Longendyke, A. N	"	"	
"	Rose, W. H	"	"	
"	Wakeman, J.*	"	"	B. S.
Akron	Akron Cement Co.*	Newstead	Erie	C.
"	Newman, H. L. & W. C.*	"	"	B. S., C.
Albany	Callanan Road Imp. Co.*	South Bethlehem	Albany	R. M.
Albion	Staines, Thomas F.*	Barre	Orleans	L.
Amsterdam	Hewitt, D. C.*	Amsterdam	Montgomery	B. S., L.
"	Vanderveer, T. B.*	"	"	B. S., L.
Aquetuck	Snyder, Carl*	Coeymans	Albany	R. M.
Auburn	Bennett, J. & Son*	Auburn	Cayuga	B. S., R. M., P. C.
"	Goodrich, L. S. & Son	"	"	B. S.
Batavia	Berthum, August	Batavia	Genesee	
"	Merrill, John*	"	"	B. S., L.
Bigelow	Williams, Charles & Co.*	De Kalb	St Lawrence	L.

DIRECTORY OF QUARRYMEN IN NEW YORK STATE – LIME-STONE – (*Continued*)

POST-OFFICE ADDRESS	NAME	LOCATION OF QUARRY		
		Town or village nearest to the quarry	County	
Boonville	Lee, Albert J.*	Boonville	Oneida	B. S., L.
Brasie Corners	Fleming, Walter	Macomb	St Lawrence	L.
"	Hall, R. G.	"	"	L., B. S.
Bellevue	Lynde, B. A.*	Bellevue	Erie	R. M.
Brooklyn	Flynn, P. H.*	Saugerties	Ulster	B. S.
Buffalo	Ambrose, E. J	Buffalo	Erie	....
"	Armbruster, Joseph*	"	"	B. S.
"	Barber Asphalt Paving Co.*	"	"	R. M.
"	Buffalo Cement Co. (lim.)*	"	"	R. M. & C.
"	Consumer's Lime Co.	Clarence	"	B. S.
"	Cumming's Cement Co.	Newstead	"	C.
"	Cutter & Bailey*	Buffalo	"	B. S.
"	Fogelsanger, D. R. & H	Amherst	"	B. S.
"	Gehres, Anna*	Buffalo	"	B. S.
"	German Rock Asphalt Co.	Lockport	Niagara	
"	Gesl, John Jr	Buffalo	Erie	B. S.
"	Grattan & Jennings	"	"	
"	Kabel, Martin*	"	"	B. S.
"	Kehr, A. P.*	Clarence	"	B. S.
"	Straub, Peter G	"	"	L.
Burlington, Vt.	Burlington Mfg. Co.†	Port Henry	Essex	M.
Canajoharie	Allen, William	Canajoharie	Montgomery	L.
"	Rapp, G.	"	"	B. S.
"	Shaper, A. E. & D. C	"	"	B. S.
Canandaigua	McNulty, Frank*	Canandaigua	Ontario	B. S.
Canton	Stevens, E. E	Canton	St Lawrence	M.
Catskill	Palmer, H. P.*	Catskill	Greene	L.
Cazenovia	Burr, J. T.	Fenner	Madison	
Chaumont	Adams & Dufort	Chaumont	Jefferson	
"	Chaumont Company	Lyme	"	B. S., R. M., L.

Chazy	Chazy Marble-Lime Co.*	Chazy	Clinton	B. S., R. M., L.
"	Goss, L. M	"	"	L.
Cherry Valley	Bastian, William	Cherry Valley	Otsego	L.
"	Eldridge, O. H.†	"	"	L.
Chittenango Falls	Keeler, Charles	Fenner	Madison	L. & C.
"	Tooke, D. J.*	"	"	B. S.
"	Winchell, W. M.	"	"	
Clayton	Denney, Leander*	Clayton	Jefferson	B. S.
Climax	Haswell, D. G.	Coxsackie	Greene	
Cobleskill	Baard, Frank*	Cobleskill	Schoharie	L.
"	Brandenstein, John*	"	"	B. S.
"	Reilly, William*	"	"	B. S.
Collinsville	Jones, Hugh D	West Turin	Lewis	L.
"	Potter, M. N	" "	"	
"	Roberts, R. W.*	" "	"	R. M., L.
"	Whittlesey, Walter	" "	"	
"	Williams, B. B	" "	"	L.
Columbia	Manning, A	Columbia	Herkimer	
Coxsackie	Day, Ambrose	Coxsackie	Greene	L.
Cranberry Creek	Kegg, Willard	Northampton	Fulton	L.
"	Warren, Willis E	?	"	
Crary Mills	Church, Ashley	Potsdam	St Lawrence	L.
Dolgeville	Dolge, Alfred*	Oppenheim	Fulton	B. S.
Dover Plains	Bensen, Geo. V	Dover	Dutchess	
East Onondaga	Hibbard, John P.*	Onondaga	Onondaga	B. S. & R. M.
East Pitcairn	Van Patten, F. A.*	Pitcairn	St Lawrence	L.
Ellenville	Van Dermark, B.	Wawarsing	Ulster	L.
Fayetteville	Bangs & Gaynor*	Manlius	Onondaga	C.
"	Ransier, Huestis B.*	"	"	B. S. & R. M.
"	Sheedy, Thomas W	"	"	C.
Fort Edward	Harris, John F.*	Whitehall	Washington	B. S.
Franklin Iron Works	Juhl, M.*	Augusta	Oneida	B. S.
Glens Falls	Glens Falls Co.*	Queensbury	Warren	L., B. S., M.
"	Jointa Lime Co.*	"	"	L., B. S.
"	Morgan Lime Co.*	Moreau	Saratoga	L.
"	Reynolds & Riordan*	Queensbury	Warren	B. S.
"	Sherman Lime Co.	"	"	L.
Gloversville	Mayfield Lime Co	Mayfield	Fulton	L.

DIRECTORY OF QUARRYMEN IN NEW YORK STATE — LIMESTONE — (*Continued*)

POST-OFFICE ADDRESS	NAME	LOCATION OF QUARRY		
		Town or village nearest to the quarry	County	
Gouverneur	Abbott, J. B	Gouverneur	St Lawrence	L.
"	Empire Marble Co.*	"	"	M.
"	Gouverneur Marble Co.*	"	"	M. B. S.
"	Northern New York Marble Co.*	"	"	M.
"	Potter, Charles A	Fowler	"	M.
"	St Lawrence Marble Co	Gouverneur	"	M.
"	Wright, H. J	Fowler	"	L.
Greenwich	Bennett, H. C.*	Greenwich	Washington	B. S.
Harris Hill	Fiegle, August	Clarence	Erie	L.
Harrisville	Brady, Mary*	Diana	Lewis	L., B. S.
Hart Lot	Carrigan, P. C	Elbridge	Onondaga	
"	Heavern, Charles	"	"	
"	Gorham, Aaron	"	"	
"	Keenan, John	"	"	
Hickory	Ingram, Vilast	Macomb	St Lawrence	L.
"	Perin, Wm	"	"	L.
Holland Patent	Hillidge, James G	Trenton	Oneida	B. S.
Hoosick Falls	Carey, William	Hoosick	Rensselaer	B. S.
"	Dolan, John*	"	"	B. S.
"	McCaffrey, Cornelius*	"	"	B. S.
Howe's Cave	Howe's Cave Assn.*	Cobleskill	Schoharie	R. M., B. S., L. & C.
"	Howe's Cave Lime & Cement Co.*	"	"	B. S. L. & C.
Hudson	Shute & Rightmyer	Jonesburg & Hudson	Columbia	B. S., R. M.
Ingham Mills	Butler, Sherman	Manheim	Herkimer	
Ithaca	Driscoll Bros. & Co.*	Ithaca	Tompkins	B. S. & R. M.
Jamesville	Alvord, E. B. & Co.*	Dewitt & Lafayette	Onondaga	B. S., L. & C.
"	Dunlap, R. & Co.*	Dewitt	"	R. M. & C., P. C.
Johnson	House, Samuel*	Johnson	Orange	L.
Jonesburg	Jones, Fred W.*	Greenport	Columbia	B. S. & M.

Joy	Horn, William	Sodus	Wayne	
Kattsbaan	Fiero, William*	Saugerties	Ulster	L.
"	Valk & Beers*	"	"	L. & B. S.
Kerhonkson	Gordon, E. H	Rochester	"	L.
Kingston	Nooue, Luke†	Kingston	Ulster	B. S.
LeRoy	Heinlich, John	LeRoy	Genesee	L.
"	Holmes, George H.*	"	"	B. S.
"	Howell, Livingston H.*	"	"	B. S.
"	Morris & Strobel	"	"	B. S.
"	Pangrazio Bros.*	"	"	B. S.
Leyden	Auer, Melchior*	Leyden	Lewis	B. S.
Lincoln	Gould, T. O	Walworth ?	Wayne	
"	Hanson, William	"	"	
Littlefalls	Jones, Hadley*	Manheim	Herkimer	B. S. & R. M.
Lockport	Heary, M. F	Lockport	Niagara	B. S.
"	Levalley, W. B	"	"	
"	Lockner, William E.*	"	"	B. S.
"	Lockport Stone Co.*	"	"	B. S.
"	Stainthorpe, C. N. & Co	"	"	B. S., R. M.
"	Tuohey, P. H.*	"	"	B. S.
"	Upson, W. H	"	"	
"	Watson, T. G.*	"	"	B. S.
"	Whitmore, Charles*	"	"	B. S.
"	Wilson, John H.*	"	"	B. S.
"	Woodward & Son	"	"	
Lowville	Babcock, William L	Lowville	Lewis	B. S.
"	Carter, L. H	"	"	B. S.
"	Gowdy, Hiram*	"	"	B. S.
"	Lyman, M. M.*	"	"	B. S.
"	Waters, John M	"	"	B. S. & L.
Lyon's Falls	Post, Orville	West Turin	"	
Manlius	Behan, James, estate of*	Manlius	Onondaga	B.S. & R. M., L. & C.
"	Brown Cement Co	"	"	
Marcellus	Malley, William*	Marcellus	"	B. S. & L.
Marcellus Falls	Walker, Laura E	"	"	C.
Mayfield	Warner, S. B	Mayfield	Fulton	L.
Mettacahonts	Gray, Stephen	Rochester	Ulster	L.
Middle Falls	Bates, H. B.*	Greenwich	Washington	B. S. & L.
"	Cipperly, John	"	Washington	

DIRECTORY OF QUARRYMEN IN NEW YORK STATE — LIMESTONE — (*Continued*).

POST-OFFICE ADDRESS	NAME	LOCATION OF QUARRY: Town or village nearest to the quarry	LOCATION OF QUARRY: County	
Middle Falls	Grouty, James M	Greenwich	Washington	B. S.
"	Kenyon, Ambrose	"	"	
"	Sullivan, Patrick	"	"	
Middleville	Mosher, W. W.*	Newport	Herkimer	B. S.
Mill Grove	Shoff, B. O.*	Mill Grove	Erie	L.
Mohawk	Humphrey, J. W.*	Columbia	Herkimer	L.
Munnsville	Adams, Frank*	Stockbridge	Madison	B. S.
"	Palmiter, Amos*	"	"	B. S. & L.
Natural Bridge	Ashcraft, F. E.*	Diana	Lewis	L.
"	Hall, E. & W.*	Wilna	Jefferson	L.
Newark, N. J.	Anderson & Moynehan*	Newcomb	Essex	L.
Newburgh	Brown, David*	Newburgh	Orange	B. S. & L.
"	Miller, Geo. W. & D. C.	"	"	L. R. M.
Newcomb	Sayre, James R. jr. & Co*	Kingston	Ulster	B. S., L.
Newport	Higgins, Gilbert	Newport?	Herkimer	
"	Morey, Newell	"	"	
"	O'Connor, George H.*	"	"	B. S.
"	Sherman, John	"	"	
"	Toumey Daniel	"	"	
New York	Duryee Portland Cement Co	Montezuma	Cayuga	C.
"	Newark & Rosendale Lime & Cement Co.*	Whiteport	Ulster	L. & C.
"	O'Connell & Hillery	Tuckahoe	Westchester	L.
"	Snowflake Marble Co.*	Pleasantville	"	M. & L.
Niagara Falls	Messing, Bernard	Niagara	Niagara	L.
"	O'Rourke, Michael	"	"	
North Litchfield	Davies, Albert R	Litchfield	Herkimer	L.
"	Dickson, Charles	"	"	L.
"	Holland, George E.*	"	"	L.
"	Salisbury, John E.*	"	"	L.

North Western	Vale, John D	Western	Oneida	L.
"	Van Dyke, John H.*	"	"	B. S.
Norwood	Hale, George W.*	Potsdam	St Lawrence	B. S.
"	Murray, James L.	" ?	"	
Ogdensburg	Howard, John F.*	Oswegatchie	St Lawrence	R. M., B. S. & L.
"	Nevin, John H.	"	"	B. S.
Onondaga Castle	Kelly Bros.	Onondaga	Onondaga	B. S.
" "	McElroy & Sons	Onondaga	Onondaga	
" "	Storrier Bros*	"	"	B. S.
Oriskany Falls	Putnam estate	Augusta ?	Oneida	
Palatine Bridge	Mohawk Valley Stone Co*	Palatine	Montgomery	B. S. & R. M.
Perryville	Hodge, Mrs. F. W	Sullivan	Madison	
"	Worlock, Cyrus*	"	"	L. & C. R. M.
Phelps	Edson, B	Phelps	Ontario	
"	Johnson, William H	"	"	B. S.
Pine Island	Brown, B. T.	Warwick	Orange	L.
"	Elston, Charles †	"	"	L.
Plattsburg	Behan, Hugh	Plattsburg	Clinton	B. S.
"	Pray, G. W	Peru	"	L.
"	Robinson, Thomas	Plattsburg	"	B. S.
Pleasant Valley	Russell, Evert †	Pleasant Valley	Dutchess	L.
Pleasantville Station	Cornell Lime Co*	Mount Pleasant	Westchester	M. & L.
Prospect	Talcott, Charles L.	Russia	Herkimer	L.
"	Thomas, Evan T*	Trenton	Oneida	B. S.
Poughkeepsie	Bain, F. R.	Dover ?	Dutchess	B. S.
"	Hufcut, H. D	"	"	
"	Lawlor, Michael	"	"	
Ravena	Day, Abraham	Coeymans	Albany	
"	DeFriest, W. V. D. H*	"	"	B. S.
"	Hotaling, David	"	"	B. S.
"	Hughes, William*	"	"	B. S.
"	McCullock, Conrad	"	"	B. S.
Rochester	Foery & Kastner*	Rochester	Monroe	R. M. & B. S.
"	Lauer & Hagaman*	"	"	R. M. & B. S.
"	Nellis, J. B. (administrator) †	"	"	B. S. & L.
"	Neuman, R. G.*	Gates	"	L.
"	Smith, B. P.*	Union Springs	Cayuga	B. S.
"	Whitmore, Rauber & Vicinus*	Rochester	Monroe	B. S. & R. M.

DIRECTORY OF QUARRYMEN IN NEW YORK STATE LIMESTONE — (*Continued*).

POST-OFFICE ADDRESS	NAME	LOCATION OF QUARRY: Town or village nearest to the quarry	LOCATION OF QUARRY: County	
Rondout	Gross, F. W.	Kingston	Ulster	B. S.
“	Lawrence Cement Co.*	“	“	C.
“	Newark L. & C. Mfg. Co.*	“	“	R. M. L. & C.
“	New York & Rosendale Cement Co.*	Rosendale	“	C.
Rossie	O'Brien, John*	Rossie	St Lawrence	L.
Sandy Hill	Drake & Stratton Co. (limited)†	Queensbury	Warren	B. S.
“	Monty, Higley & Co.*	Kingsbury	Washington	B. S.
“	Sturtevant, D.	South Glens Falls	Saratoga	B. S.
Saratoga Springs	Slade, Charles G.*	Greenfield	“	B. S.
“	Wagar, Isaac F.*	Milton	“	B. S.
“	Wing, Prince; estate	“	“	L.
Sauquoit	Thurston, W. W.	Paris	Oneida	
Schoharie	Becker, Clinton L.	Schoharie	Schoharie	B. S.
“	Brown, Albert*	“	“	B.S., R.M.& C., P.C.
Seneca Falls	Fisher, John	Fayette	Seneca	B. S. & L.
Sharon Springs	Mallett, F. C.	Sharon	Schoharie	
“	Smith, Henry S.*	“	“	L.
“	Smith, Jefferson†	“	“	B. S.
“	Smith, W. T.*	“	“	B. S. & R. M.
Shelby	Simonds, E. B.†	Shelby	Orleans	L.
Sing Sing	Ossining Lime Co.*	Ossining	Westchester	L.
Skaneateles Falls	Starr, Levi	Sennet	Cayuga	B. S.
Smith's Basin	Keenan Lime Co.*	Kingsbury	Washington	L.
“	Nichols, D. & Son	Hartford	“	L.
Smith's Landing	Gould, J. H.*	Catskill	Greene	B. S.
“	Massino, William	“	“	B. S.
Sodus Center	Mather, E. B. & Co.*	Sodus	Wayne	L.
“	Munn, Gardner A.*	“	“	L.
South Greenfield	Wing, Elihu	Milton	Saratoga	L.
Split Rock	Connors, James	Onondaga	Onondaga	B. S.

Split Rock	Crowley, Cornelius*	Onondaga	Onondaga	B. S.
Springfield Center	McDonough, William*	Springfield	Otsego	B. S.
St. Johnsville	Allter, Bros.*	St Johnsville	Montgomery	B. S., R. M.
"	Fitzer, C.*	"	"	B. S.
"	Hilligar, Chas.	"	"	
"	Fox, D.	"	"	
"	Nagle, Thomas	"	"	
"	Place, Daniel	"	"	
"	Smith, Albert A.	"	"	L.
"	Smith, W. C.*	"	"	B. S.
Stoneco	Hudson R. Stone Supply Co.	Stoneco	Dutchess	R. M.
Stone Ridge	Basten, John*	Marbletown	Ulster	B. S. & L.
"	Davenport, Solomon*	"	"	L.
Syracuse	Alvord, A. E.	Manlius	Onondaga	L., C., R. M.
"	Britton & Clark	Onondaga	"	L. & R. M.
"	Hughes Bros.*	"	"	B. S.
"	Thomas, C.*	"	"	B. S.
"	Solvay Process Co.*	"	"	B. S. & R. M.
"	Wadsworth, George*	"	"	B. S.
Three Mile Bay	Barron, John J.*	Lyme	Jefferson	B. S.
Thurman	Pelletier, John	Thurman	Warren	M.
Ticonderoga	Joubert, Israel*	Bolton	"	B. S.
Tomkins Cove	Tomkins Cove Stone Co.	Tomkins Cove	Rockland	R. M.
Towner's	Penny, P. D.*	Patterson	Putnam	B. S.
Tribe's Hill	Hurst, Henry & Son	Mohawk	Montgomery	
"	Putman, J. G	"	"	
"	Shanahan, James	"	"	B. S.
Troy	Cheney, W. D. & Son	Smith's Basin	Washington	L.
Tuckahoe	New York Quarry Co.	Eastchester	Westchester	M.
"	Norcross Bros	"	"	M.
"	Tuckahoe Marble Co.	"	"	M.
"	Young, James S	"		
Union Springs	Shalebo, J. L.	Springport	Cayuga	L.
"	Wood, George P.*	Hamburg	"	B. S.
Utica	Callahan, Ed.*	Trenton	Oneida	B. S.
"	Conley, F. E.*	Oriskany Falls	"	R. M.
Verplanck	Brown & Fleming*	Verplanck	Westchester	R. M.
Walworth	Mann, Owen	Walworth	Wayne	L.

DIRECTORY OF QUARRYMEN IN NEW YORK STATE — LIMESTONE — (*Continued*).

POST-OFFICE ADDRESS	NAME	LOCATION OF QUARRY: Town or village nearest to the quarry	LOCATION OF QUARRY: County	
Walworth	Read, John*	Walworth	Wayne	L.
Waterloo	Babcock, Dwight*	Fayette	Seneca	B. S. & R. M.
Warwick	Burt, Thomas*	Warwick	Orange	B. S.
Watertown	Cory, Henry S.*	LeRay	Jefferson	L., B. S.
"	Gould, A	Watertown ?	"	
"	Hunting, S. E	Pamelia	"	B. S.
"	Phillips, Patrick*	Watertown ?	"	
"	Williams, E.	" ?	"	
Wawarsing	Hoornbeck, Charles*	Warwarsing	Ulster	L.
West Troy	Mark, George*	Glens Falls	Warren	B. S.
West Walworth	Hanson, William	Walworth	Wayne	
West Winfield	Bradley, A. P.*	Winfield	Herkimer	L.
Whitfield	Barley, Albert*	Rochester	Ulster	L.
"	Dixon, Benjamin C.*	"	"	L.
Whitehall	Adams, Terry	Whitehall	Washington	
"	McLaughlin, John	"	"	B. S.
Williamsville	Young, J. B. & F. H.*	Williamsville	Erie	L. & B. S.
Willsboro Point	Frisbie, C. W.*	Willsboro	Essex	B. S.
Wolcott	Post, Alonzo*	Butler	Wayne	L.
"	Walker, Charles J.†	"	"	B. S. & L.
Wolcottville	Luckman, William J.*	Royalton	Niagara	L.

Sandstone

POST-OFFICE ADDRESS	NAME	Town or village nearest to the quarry	County	
Albany	Fuller's Son's Wm.*	New Baltimore	Greene	B. S.
Albion	DeGraff & Roberts	Barre	Orleans	B. S.
"	Garrett & Atkinson	"	"	B. S.
"	Goodrich & Clark Stone Co.	"	"	B. S.
Belfast	Lang, James†	Belfast	Allegany	B. S.

Belmont	Johnson, James	Amity	Allegany	B. S.
Belvidere	Dibble, Albert	"	"	B. S.
Canajoharie	Shaper, A. E	Canajoharie	Montgomery	B. S.
Clayton	Wilber, S. H	Clayton	Jefferson	B. S.
Cleveland, Ohio	Albion Stone Co*	Barre	Orleans	R. M., B. S.
Clinton	Dawes, Charles*	Kirkland	Oneida	B. S.
"	McCabe, John	"	"	B. S.
"	Moore, Richard	"	"	B. S.
Cooperstown	Wood, John	Middlefield	Otsego	B. S.
Corning	Bedient, James H	Corning	Steuben	B. S.
"	Kelley, John	"	"	B. S.
Dansville	Schubmehl, Martin J*	Dansville	Livingston	B. S.
Dormansville	Stewart, William	Westerlo	Albany	B. S.
East Guilford	Miller, Wm.†	Guilford	Chenango	B. S.
Elmira	Symonds, A. D	Elmira	Chemung	B. S.
Fort Ann	Holmes, Andrew D	Fort Ann	Washington	B. S.
"	Parrish, Franklin	"	"	B. S.
"	White, Jenkins	"	"	B. S.
Fort Jackson	Downey Bros	Hopkinton	St Lawrence	B. S.
Frankfort	Joslin, M. T.*	Frankfort	Herkimer	B. S.
Fulton	Granby Brownstone Co	Granby	Oswego	B. S.
"	Jennings, Orvill J	Volney	"	B. S.
Goodyears	Barger, J. G†	Genoa	Cayuga	B. S.
Grand View	Brown, Wm. H	Orangetown	Rockland	B. S.
Hammond	Finegan, John C*	Hammond	St Lawrence	B. S., F.
"	Foster, H. A	"	"	B. S.
"	Parmeter, D. E	"	"	B. S.
"	Stanley, W. H	"	"	B. S.
Haverstraw	Demarest, P. E	Haverstraw	Rockland	B. S.
Highland	Clearwater, F. S	Lloyd	Ulster	B. S.
Himrod	Cheney, Louis A.*	Himrod	Yates	B. S.
Hindsburg	Baldwin & Hinds	Murray	Orleans	B. S.
"	Burns, L. G	"	"	B. S.
"	Chadwick Bros	Albion	"	B. S.
"	Chadwick, Thos. Jr	Murray	"	B. S.
Holley	Downs & Bowman †	Clarendon	"	B. S., F.
"	O'Brien & Co	Murray	"	B. S.
Hornellsville	Cobb, J. F	Hornellsville	Steuben	B. S.
Hulburton	Fancher & Newsome*	Murray	Orleans	B. S., F.

DIRECTORY OF QUARRYMEN IN NEW YORK STATE — SANDSTONE — (*Continued*).

POST-OFFICE ADDRESS	NAME	LOCATION OF QUARRY: Town or village nearest to the quarry	LOCATION OF QUARRY: County	
Hulburton	Ford A. H	Murray	Orleans	B. S.
"	Gwynne, C. F	"	"	B. S.
"	Hamilton Chas. J	"	"	B. S.
"	Hebner, John	"	"	B. S.
"	Lardner, Thomas	"	"	B. S.
"	Phillips, Marcus	"	"	B. S.
"	Squire, A. J	"	"	B. S.
"	Sturaker & Sullivan	"	"	B. S.
"	Von York, Constantin	"	"	B. S.
Ithaca	Fowles, Joseph *	Ithaca	Tompkins	R. M., B. S.
"	Mc. Clune, G. C †	"	"	B. S.
Jamestown	McVeigh, John	Ellicott	Chautauqua	B. S.
Lewiston	Hotchkiss, L. W	Lewiston	Niagara	B. S.
Lockport	Kinney, Rebecca	Lockport	"	B. S.
"	Spalding Wm	"	"	B. S.
"	Whitmore, Chas.*	"	"	R. M., B. S.
Malden	Ulster Bluestone Co *	Quarryville	Ulster	B. S. & F.
Malone	Bashaw, Levi	Malone	Franklin	B. S.
"	Morris, Antoni	"	"	B. S.
"	Paddock S. A	"	"	B. S.
Medina	Garrett, Thos	Ridgeway ?	Orleans	
"	Gorman, Chas. A *	Murray, Barre, Ridgeway	"	B. S. & F.
"	Gorman & Stork	Barre	"	B. S.
"	Gotts & Stork	"	"	B. S.
"	Horan, Patrick	Ridgeway	"	B. S.
"	Horan, Mrs. S. J	"	"	B. S.
"	Kearney & Barrett	"	"	B. S.
"	McCormick, A. J.	"	"	B. S.
"	Mooney Bros.	"	"	B. S.

Medina	Noble & Lyle	Ridgeway	Orleans	B. S.
"	O'Reilly, Bernard	Murray	"	B. S.
"	Scanlon, Martin	Barre	"	B. S.
"	Slack, Michael	Murray	"	B. S.
"	Stark, Joseph	Ridgeway	"	B. S.
"	Swett, A. L.*	Medina	"	R. M., B. S.
"	Wall, Wm. H. Sup't Holloway Quarries†	Ridgeway	"	B. S.
Middleburg	Bishop, Amberson	Middleburg	Schoharie	B. S.
Monroe	Davison, John G.*	Monroe	Orange	B. S. & F.
New Hudson	Searle, Mr.	New Hudson	Allegany	B. S.
North Cohocton	Whitney, Theo.	Cohocton	Steuben	B. S.
Nyack	Puff, Nelson	Orangetown	Rockland	B. S.
"	Smith, Dan F.	"	"	B. S.
Olean	Olean Bluestone Co	Olean	Cattaraugus	B. S.
Olive	Bogart, E. H.*	Olive	Ulster	B. S. & F.
Oswego Falls	Faulkner, James	Granby	Oswego	B. S.
Oxford	Burns, Edward	Oxford	Chenango	
"	Clark Bluestone Co. F. G.*	"	"	B. S. & F.
"	Coman, Wm.*	"	"	B. S. & F.
"	Hogan & Britt	"	"	
"	Johnston & Kertsner	"	"	
"	Keeley Bros.	"	"	
"	Oldfield, James	"	"	
"	Woods, Theodore	"	"	
"	Young, Richard	"	"	
Penn Yan	Cornwell, Geo. R.	Milo	Yates	B. S.
Portageville	Genesee Valley Bluestone Co*	Genesee Falls	Wyoming	B. S.
Port Henry	Bond, L. W.	Moriah	Essex	B. S.
Potsdam	Clarkson Quarries*	Potsdam	St Lawrence	B. S., F.
"	Merritt & Tappan	"	"	B. S.
"	Potsdam Red Sandstone Co	"	"	B. S.
Rexford Flats	Benedict, Levi	Aqueduct	Schenectady	B. S.
Rochester	Brady, Gilbert*	Albion	Orleans	B. S.
"	Brown, Henry S.	Rochester?	Monroe	
Rockville	Searl, Abram*	Belfast	Allegany	B. S.
Saugerties	Burhans & Brainard*	Saugerties	Ulster	B. S., F.
Schenectady	Shear, Albert & Co*	Aqueduct & Duanesburg	Schenectady	R. M., B. S.
Shelby Basin	LeValley, John*	Ridgeway	Orleans	B. S. & F.
South Berne	Bailey, David*	Westerlo	Albany	F.

DIRECTORY OF QUARRYMEN IN NEW YORK STATE — SANDSTONE — (*Continued*).

POST-OFFICE ADDRESS	NAME	LOCATION OF QUARRY	
		Town or village nearest to the quarry	County
South Hammond	Seymour & Edgar	Hammond	St Lawrence B. S.
St Johnsville	Smith, W. C	St Johnsville	Montgomery
Trumansburg	Biggs, D. S. & Sons.*	Ulysses	Tompkins B. S. & F.
Utica	Conley, F. E.*	Higginsville	Oneida R. M. & B. S.
Warsaw	Warsaw Bluestone Co	Rock Glen	Wyoming B. S.
Washington Mills	Griffiths, Wm	New Hartford	Oneida B. S.
"	Mallory, J. P	"	" B. S.
"	Thompson, E. F	"	" B. S.
"	Trimbey, H. J.*	"	" B. S.
Watkins	Higgins, D. H.*	Dix	Schuyler B. S.
Watts Flats	Gould Fred H.*	Harmony	Chautauqua B. S.
Waverly	Boget, M. L.*	Barton	Tioga B. S.
"	Fleckenstine, J. W	"	"
"	Murray, John H	"	"
Whitehall	McLaughlin, John	Whitehall	Washington B. S.

Bluestone

Bluestone is a variety of sandstone, which, by reason of its even texture can be cut or sawed into any desired form and is therefore peculiarly available for house trimmings of various kinds. In general, the layers in the quarries vary from an inch to several feet in thickness; the thinner of these are used for flag stones and the thicker are cut into dimension stone for building purposes.

The bluestone industry is chiefly located in Ulster county and the quarries are almost innumerable but the business is controlled by a few large dealers who are located at points favorably situated for shipment and who, to a considerable extent, buy stone from the men who quarry it. Bluestone is also produced in the counties of Albany, Greene, Sullivan, Delaware and Chenango in Eastern New York and in Cattaraugus and Wyoming counties in Western New York.

The geological horizon of the commercial bluestone is very near the dividing line between the Hamilton and Portage groups. It is, however, not usually possible to determine in which of these groups a given quarry belongs owing to the great scarcity of fossils.

*PRODUCERS OF BLUESTONE

POST OFFICE ADDRESS	NAME	Town or village nearest to the quarry	
	Albany county		
Reidsville	Otto Bennet*	Berne	F.
South Berne	Bailey, David*	Westerlo	F.
	Cattaraugus county		
Olean	Olean Bluestone Co.	Olean	B. S.
	Chenango county		
Oxford	Clarke Bluestone Co. F. G.	Oxford	
Tyner	Loomis, Perry*	Smithville	B. S.
	Delaware county		
Fish's Eddy	Martin, Geo	Hancock	
Hales Eddy	Kingsbury, O. M. & Co.*	Tompkins	B. S., F.
Hamden	Kenny, James*	Hamden	F.
Hancock	Cotter Bros.*	Hancock	
"	Kirkpatrick Bros	"	
Long Eddy	Kenny Bros	"	
" "	Peak, Cyrus*	"	F.
Lordville	Curry, John	"	
Peakville	Merritt, Geo. W.*	"	B. S., F.
"	Staib, J. J.	"	
Rock Rift	Huntington, E.	Tompkins	
Stockport Station	Morse, J & Co	Hancock	
Walton	Gray & Marvin†	Walton	
"	St John, H. E.*	"	
"	Warner, G. T.*	"	B. S., F.

* PRODUCERS OF BLUESTONE — *concluded*

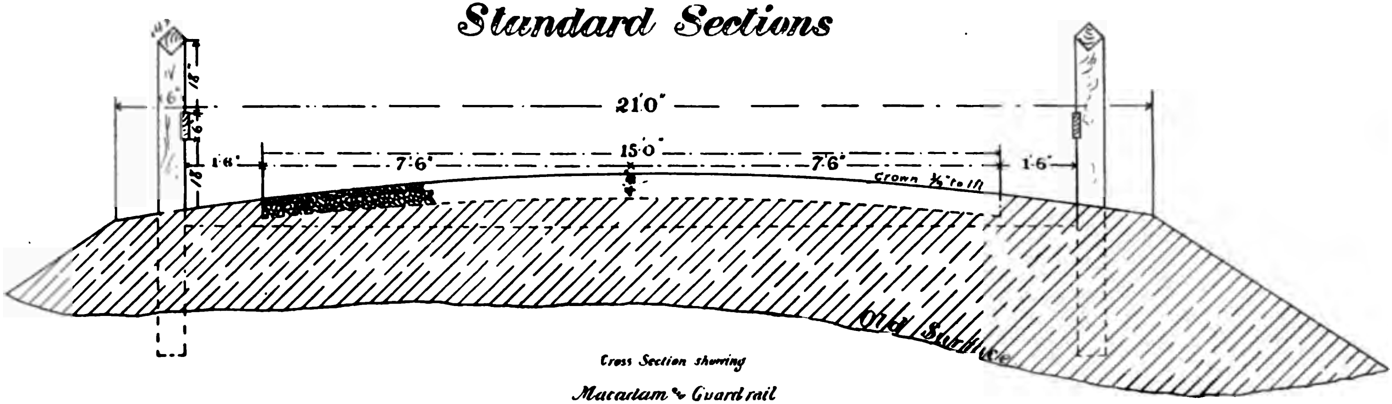
POST OFFICE ADDRESS	NAME.	Town or village nearest to the quarry	
	Greene county		
Palenville	Lamouree, F. & Co.*	Catskill	F.
"	Newkirk, Isaac*	"	
	Sullivan county		
Callicoon	Persbacker Bro's & Co.*	Callicoon	B. S., F.
Callicoon Depot	Dering, John	"	
Hankins	Manny, Anthony*	Fremont	B. S., F.
Long Eddy	Dunn & Co	"	
Narrowsburg	Engelman, Geo. W	Tusten	
Roscoe	Gregg & Miller	Rockland	
	Ulster county		
Allaben	McGregor, S	Shandaken	
Brodhead	Hungerford, Alonzo	Olive	
"	Lyons L	"	
Glenford	Burton, H	"	
"	Krom, Wm	"	
Hurley	Ostrander, Samuel	Hurley	
Kingston	Roger & Tappan, dealers only		
Lomontville	Dunn, Patrick	Marbletown	
"	Rose, Andrew	"	
Malden	Ulster Bluestone Co.*	Quarryville	B. S., F.
Marbletown	Clearwater, Jacob	Marbletown	
"	De Graff, Wm	"	
Olive	Bogart, E. H.†	Olive	F.
Olive Bridge	Gemmell, James B.	"	F.
Phœnicia	Simpson, A. J	Phœnicia	
Plattekill	Longendyke & Co	Plattekill	
"	Sheffell, F. & Co	"	
Quarryville	Carnwright, Alphonso	Saugerties	
"	Fitzpatrick, Daniel	"	
Rondout	Boice, Hewitt, dealer only		
Sawkill	Peppard, Michael*	Kingston	B. S.
"	Walsh, Wm. & Sons*	"	B. S.
Stone Ridge	Turner, C. C.*	Marbletown	
Stony Hollow	Cassidy, Owen	Kingston	
"	Murtha, Michael	"	
West Hurley	Connors, Thomas*	Hurley	
West Saugerties	Carn, J. & Sons	Saugerties	
West Shokan	Boice, Lemuel	Olive	
Wilbur	Osterhoudt, Julius*	Kingston	B. S., F.
Woodstock	Lasher, D.*	Woodstock	F.
	Wyoming county		
Portageville	Warsaw Bluestone Co	Gainesville	B. S.
"	Genesee Valley Bluestone Co	Genesee Falls	B. S.

* For a complete list of all persons engaged in quarrying bluestone see Bulletin No. 15, New York State Museum.

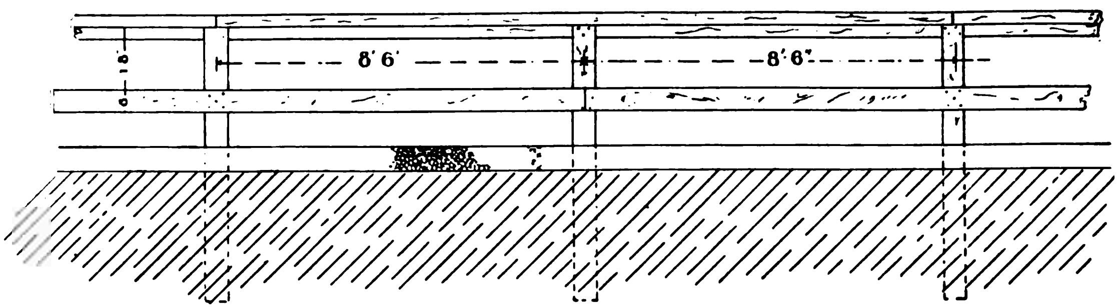
The foregoing directory of quarries and quarrymen, while probably not complete is very nearly so. As already indicated in the chapter on road materials, only a part of the quarries yield stone which is entirely satisfactory for road building. The reports of the Massachusetts Highway Commission, however, show that where the best material is not obtainable, other material can be put to a very good use, and a sandstone may make a very satisfactory foundation, when covered with trap or even with limestone, if nothing more desirable is available. Roads built in this way probably require more engineering skill in their construction and more careful watching in maintenance and repair. The local problems must be worked out in the future by actual experiment under the supervision of competent road engineers.

PLATE I.

Standard Sections



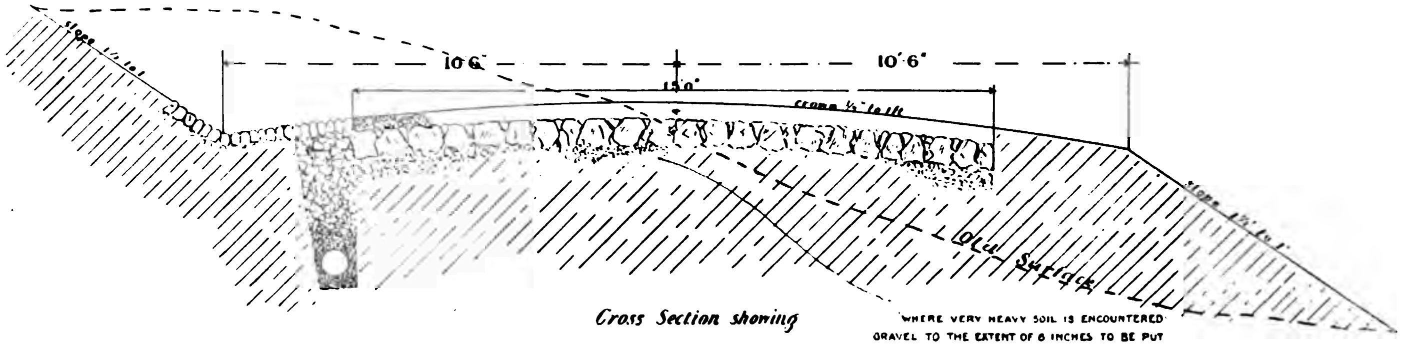
Cross Section showing
Macadam & Guard rail



Longitudinal section thro centre showing Macadam & rail

MASSACHUSETTS HIGHWAYS.

PLATE II



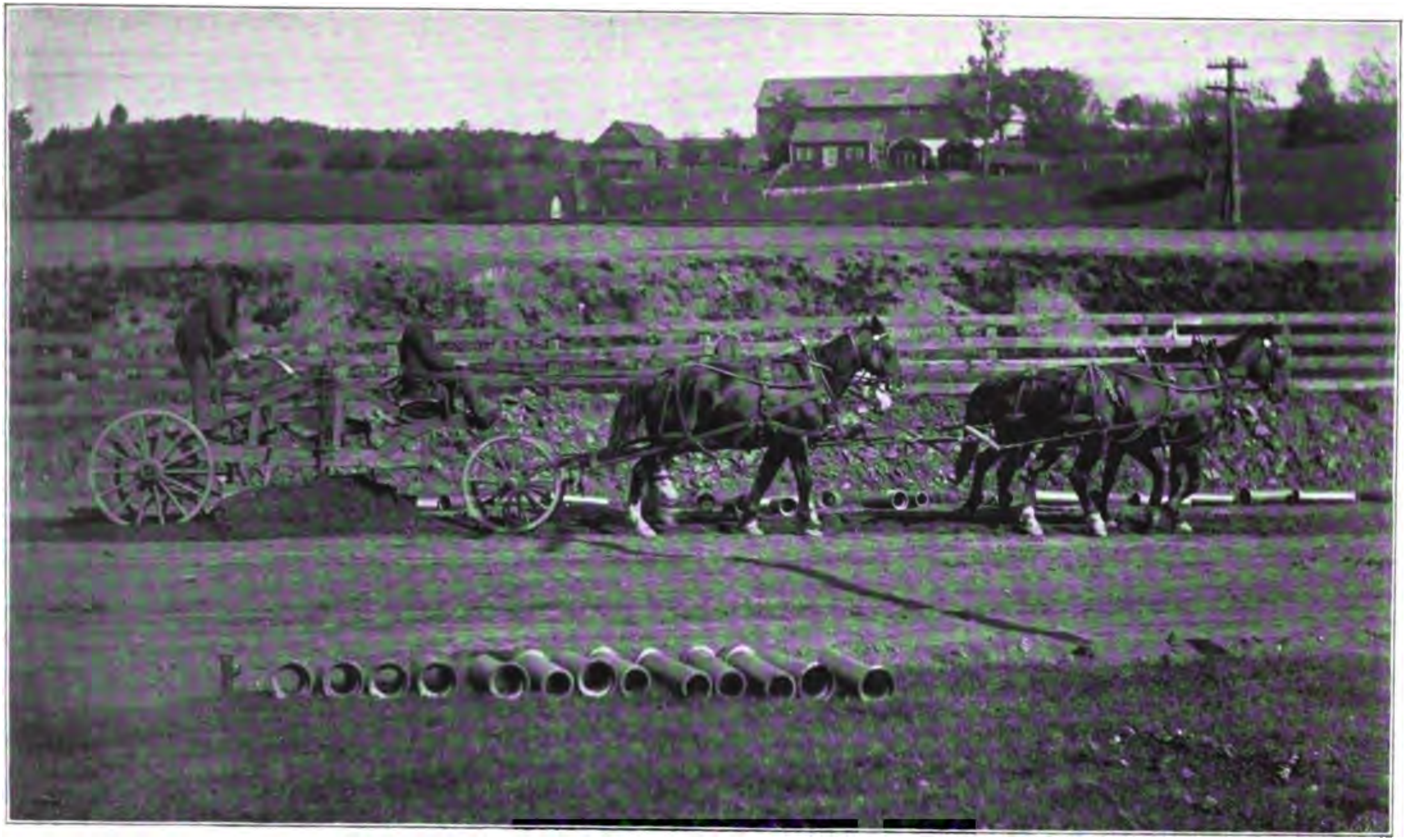
Cross Section showing

Drain, Macadam, Telford & Gutter

MASSACHUSETTS HIGHWAYS.

WHERE VERY HEAVY SOIL IS ENCOUNTERED GRAVEL TO THE EXTENT OF 6 INCHES TO BE PUT UNDER TELFORD.

PLATE III.



Westfield Road, Mass., 1894.
View showing the road machine at work grading the sub-grade.

PLATE IV.

WESTFIELD ROAD, MASS., 1894.
View showing the method of constructing a drain in clay or other wet soil.

PLATE V.

Westfield Road, Mass., 1894.
View showing details of drain.

PLATE VI.

WESTFIELD ROAD, MASS., 1894.
View showing sub-grade graded and rolled, also the broken stone in place.

PLATE VII.

WESTFIELD ROAD, MASS., 1894.
View showing sub-grade graded and rolled, also the broken stone being put in place and steam roller at work

PLATE VIII.

WESTFIELD ROAD, MASS., 1894.
View showing method of laying Telford foundation on a gravel bed.

PLATE IX.

WESTFIELD ROAD, MASS., 1894.
View showing Telford road in process of construction

PLATE X.

WESTFIELD ROAD, MASS., 1894.
View showing the finished roadway, together with steam roller at work.

PLATE XII.

WESTFIELD ROAD, MASS., 1894.
View showing completed road.

PLATE XIII.

Westfield Road, Mass., 1894.
View showing completed road with guard-rail.

PLATE XIV

Westfield Road, Mass., 1894.
View showing completed road with bridge and guard rail.

INDEX

The superior figure points to the exact place on the page in ninths; e. g. 93^7 means seven ninths of the way down page 93.

Map of the State of New York Showing the Location of Quarries of Stone Used for Building and Road Metal

New York State Museum

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University of the State of New York

BULLETIN

OF THE

New York State Museum

VOL. 4 No. 18

NOVEMBER 1897

POLISHED STONE ARTICLES

USED BY THE

NEW YORK ABORIGINES

BEFORE AND DURING EUROPEAN OCCUPATION

PREPARED BY

WILLIAM M. BEAUCHAMP, S. T. D.

ALBANY

UNIVERSITY OF THE STATE OF NEW YORK

1897

CONTENTS

INTRODUCTION

The preliminary paper on our aboriginal articles of stone comprised those which were simply chipped, and these are much more abundant and widespread than those treated of in this bulletin. The latter, however, show almost incredible patience and skill in their higher forms, as well as taste in selecting materials. They also give hints of superstitions and ceremonies not yet thoroughly understood, and therefore not now discussed. As before, this paper has been prepared and illustrated by the Rev. W. M. Beauchamp, S. T. D., the figures being from his large collection of original drawings, made in nearly all parts of New York, but mostly from the central portion. It is probable that the southwestern counties might add a few forms, as that region included a portion of the mound builders' country, and was a border land. A few illustrations might have been added from other writers, but neither these figures nor the descriptions were deemed accurate enough for the present purpose. Those given have been carefully prepared, and every detail has been represented wherever opportunity was afforded.

POLISHED STONE IMPLEMENTS OF THE STATE OF NEW YORK

In considering polished stone articles as a class, it is necessary to divide some departments, as pipes, ornaments, and vessels of various kinds, much alike in form and use, but not in material. The modes of manufacturing these, however, are sometimes so different that no farther excuse need be made. Clay and stone specially mark eras in human progress.

Under this head will also be included picked implements, for picking was commonly part of the process of forming polished articles, which are found in all stages of development. The picked implement was rarely finished. Sometimes grinding was the first act of all, but not in general. A few stones, naturally formed for use, might receive an edge at once. More commonly they were chipped, picked and polished as time or needs permitted. This is most frequently seen in the case of celts and gouges, where the same site may yield every gradation, from the rudest to the finest, and sometimes unite every process in one implement.

The number of unfinished articles of a high grade is quite suggestive, many of these being found on small camps, not indicative of long continued residence. Among others, tubes, banner stones and pipes were thus carried about, to be completed in the leisure moments of camp life. Many of the finer finished articles were also carried on journeys, indicating some possible use away from home, more superstitious or common place than ceremonial. Some features of this distribution will appear in considering these. The locality in which others were found will point out modes of travel, and perhaps indicate whence the travelers came.

Some of the best results of New York work, however, will be in determining the age of many articles hitherto undated, and in sometimes assigning them to their true makers. Much progress has already been made in this comparative study, and a thorough exploration of a few well known sites would give valuable results. Several kinds of stone pipes were made only within the historic period, and the red pipe stone of the West first appeared in New

York but little over 200 years ago. Articles of shell have also been sadly misunderstood.

As to material, there are also valuable suggestions in some of these articles of polished stone. The aborigines had taste in selection when they required ornaments, and the Huronian or striped slate frequently appears, a few celts even being made of this. This indicates commerce, for it came from places farther north and west. Travel and traffic existed then as now. Gorgets are usually of fine stone, and are rarely unfinished. As a rule, they were brought here in perfection. For celts, however, any pebble might answer, and many are of ordinary field stones, always accessible to the common people. The abundance of basalt celts, even on recent sites shows a choice in material, and some of the green stones are beautiful indeed. Pestles are often well worked, but yet oftener are slightly adapted pebbles. Some are of great size. Hammer stones survived almost every thing else, but stone balls, used in war clubs by their fathers, are preserved by New York Indians yet. Such features will be more fully seen as we proceed.

When the white man came to New York, the Mahikans and other kindred nations occupied the Hudson River and the seacoast. West of these was the territory of the Iroquois, Andastes and Eries, also of one family. At that period the Iroquois at least used but little stone, nor are the finer early articles found on their earlier sites. As a rule, their pipes were of clay, ingeniously ornamented, and whether they had ever used or made others may be a question. Obtaining suitable tools from the white man, they afterwards made pipes of stone, in a sense going back to the stone age. The delicate drilling of the pipe stone, so often seen, was unattainable with aboriginal tools, and this is true of the small shell beads. Pipes and ornaments were articles of common use, however, and some nations were celebrated for their work of this kind, but we need never forget that most of their finery came from frailer materials. Within the historic period it is probable that many of the New York stone pipes were made by the Cherokees, as in earlier colonial times they were made in New England. Many stone implements, common elsewhere, are notably absent here, showing that some large nations

never penetrated this State. This is the case with the grooved axes and chungke stones. On the other hand the makers of some slate knives, amulets, and other articles here, never penetrated the South. So to speak, there was an aboriginal Mason and Dixon's line.

That many articles required a long time to finish, seems plain, and yet this time may have been overestimated, as in the early ideas of arrow making and other primitive arts. A dexterous workman went on confidently, and his simple tools were sometimes far more efficient than we think. Skill was more than instruments. Sometimes the stone was wrought while fresh and soft, hardening afterwards by exposure and use, as in the case of the Cherokee pipes; but a good flint or gritty stone cut many materials with great rapidity and ease. The fine finish may have been much slower work, reserved for a master hand. Drilling was done in various ways and most gorgets seem to have been perforated with flint. Banner stones were sometimes partially drilled with this, as appears in some unfinished pieces. Sometimes a tubular drill was used, as we find in the same way; sometimes a gouging process was employed. Precisely how the picking was done may be less plain, but effective hard and sharp stones are not rare. Usually it is very neat and uniform even where the material is hard. As polishing was the last process it began with the most essential parts of the implements as the cutting edge, where it often preceded the picking.

That many early implements of polished stone were not used by the later Indians, and indeed were unknown to them, is now well understood. This, like the same fact in chipped stone, points to a great and probably sudden change. They were not perpetuated by descent, nor acquired by conquest, but were simply lost arts, because there were intervals between the early and later comers. The stone gorget, banner stone, amulet, tube, boat stone, slate knife, grooved axe and gouge, had no place at all among the Iroquois, historic or prehistoric, yet all these occur more or less in their ancient territory. These, too, were among the finest of American articles of polished stone, and yet were utterly unknown to them, as far as appears. Thus, whoever was here before their coming had little in common with them, except in the very simplest

things. This difference is so great of itself as almost to prove them a different race, and this appears in other ways. In a broad way the Algonquin family might be included in this view.

Occasionally location has importance in considering probable use. Two grooved boulders in position may materially affect our opinion of their use and origin. The abundance of stone plummets in certain places indicates a local and special purpose. Two forms of polished slate knives may have great ethnological importance, and the almost utter absence of other things points out early differences otherwise unknown. More light still may result from farther research and clearer judgment, specially as comparative study goes on.

There is now little reason to doubt that the use of polished stone in America is nearly or quite as old as that of chipped articles, specimens of the former occurring geologically as early as the latter, if the tales of scientists are true. Indeed the idea of sharpening by rubbing or grinding would be quite as primitive and natural as any other, and it would soon be a question of the best use of material. Stones with a good cleavage would be chipped; those of a different character, ground. Bone or horn are often so well adapted for use naturally or by accident, that the slight grinding required would be at once suggested. Divesting ourselves of all prejudice, it would seem that the two arts would go hand in hand, as was certainly the case in New York. In this State the older polished stone articles are not only the finest, but are often far older than those of flint.

There was a period of decadence in polished stone work in New York before the coming of the white man. Shell, bone and horn had taken the place of some things, and clay of others. The stone pipe had largely disappeared and the polished stone axe or celt was almost the only fine article surviving in pristine beauty. These were soon to pass away, but steel tools occasioned a revival of ornamental stone work. Pipes of this material were made again; pipestone came east through the wars of the Iroquois, and was delicately wrought and drilled in great quantities, often by the white man's taste and skill; always with his tools. Small shell beads were made and distributed in prodigious numbers through the same means, but the flint arrow and stone axe utterly disappeared. The

return to the stone age, such as it was, came through the white man and not through the red.

It often happens that a number of stone articles can be assigned to one maker, as certainly as we can tell who made an old violin, although we know not his name. Things hundreds of miles apart will be found of some peculiar material and form, which can hardly be accidental. They will not be many in number, but they will have individual character. We recall many such. The skilful aboriginal artificer was as highly honored as any among civilized men, and his work had a wide reputation. In other lands early records show this in words which we can read. Here the record exists only in stone.

Usually articles which required much drilling of any kind, were blocked out before this was done. Thus all percussion was avoided after the perforation was complete, while sufficient material was left to allow for any deviation from right lines in drilling. Grinding and polishing then safely proceeded. Polishing and perforation sometimes went on together with disastrous results, a break in the surface spoiling the pipe or banner stone. The extent to which this drilling was carried is often surprising and the same may be said of its accuracy, specially when, as in many tubes and banner stones, it was made from both ends, meeting in the center. In its way it was as great a feat as some modern tunneling. Rarely does it deviate from a straight line.

CELTS

The grooved axe, as will hereafter appear, is rare in most of New York, and its place is supplied by some of the many forms of celts, often known as deer skinners. These are occasionally roughened toward the upper part of the lateral edges, to give a better grip to the handle. These axes were in use when Champlain encountered the Mohawks on Lake Champlain in 1609, although some had already obtained iron axes from the traders, who had frequented the lower St. Lawrence for more than 70 years. He was surprised that they could do so much with such poor tools, and these must have been far more effective than most antiquarians have thought, for in this instance fire was not used. He said they 'began to hew

down trees with villainous axes, which they sometimes got in war, and others of stone, and fortified themselves very securely.'

Usually, according to David Cusick, fire was applied to trees, and when these were felled, fresh fires were kindled where these were to be cut off in lengths. The fire was the active agent; the celt or stone axe was employed in scraping away the charred wood. Each woman had several fires to attend, and the work was done quite rapidly. At Onondaga now, the Indians use the same means in hollowing out the large wooden mortars still used by them. Burning and chipping go on alternately, a process familiar to our own early settlers.

The mode of handling is of interest, but was not always the same, and many ways have been described. Fig. 1 presents one remarkable and antique example. It is a celt of the common rounded form found in the peat and muck at Chittenango Creek long ago, seven feet under ground. It is the only ancient handle locally preserved, and has suffered much from age yet it is still fifteen and one half inches long by two and one quarter broad. It tapers from the axe to the end of the handle. The orifice in this is shown at *b*, and has evidently been finished, at least, by heat. In this the fine greenstone celt, elliptical in section, exactly fits. This is five and three eighths inches long and two wide, the form being quite common. It was dug up in excavating for the canal feeder.

Fig. 2 is an angular form of brown sandstone, found in the town of Cicero, four and five eighths inches long by two and one eighth wide. This form seems more frequent in New York than elsewhere, and is from four to six sided in its varieties, the angles never being rounded. One of the surfaces is always broad and flat, and two of them meet the others at a broad angle. They are somewhat common at Onondaga and Oneida lakes.

Fig. 4 is of an unusual form and material, being a very broad and flat celt of green striped slate, three and three quarters by three and one eighth inches. The outline is much like that of a modern axe, and it is much twisted in section. This was found, with a similar one, at Jack's Rifts, on the Seneca River.

Fig. 6 is a chisel of brown sandstone, almost cylindric, but with several flattened sides. These sides are nearly parallel. It is five

and five eighths inches long and one and one eighth inches wide, with neatly rounded ends. It is a rare form, and was found at Baldwinsville.

Fig. 7 is also a somewhat rare, but widely distributed form. It is flat or nearly so on one side, and more convex on the other. They usually have a broad cutting edge at one end, and are rounded at the other. This one comes to a sharp point, and is rounded and sharp at the broad end. It is of grey sandstone, three and one eighth by nine sixteenths inches and comes from Wood Creek, east of Oneida Lake.

Fig. 8. is of the normal form of this type, and is of brown sandstone, four by three quarters inches. It is sharp at both ends, the more pointed one being rounded, and comes from Baldwinsville, where they are somewhat frequent.

Fig. 9 is of green striped slate, and approaches the boat form. The ends are rounded and sharp. It is four and one eighth inches by three fourths deep, and comes from Chittenango Creek. There are many of this form, but their use is not clear.

Fig. 10 is another of the angular celts, and a still rarer form. It is of brownish drab sandstone, eight inches long by two and one eighth wide, and of a tapering form. There is a raised medial line on each broad surface, which, for half the length, has been gradually ground down to the broad cutting edge. The small end is brought to a neat point. Angles like these are hardly rare and yet are seldom so pronounced. This comes from the village of Baldwinsville.

Fig. 11 is a small black basalt chisel, angular and sharp, two and one eighth inches by one fourth broad. It is a very neat specimen of these small implements, and comes from Seneca River. Fig. 12 is another of these small celts from the same place, but thicker and more ridged on one side. It is of greenstone, two and one quarter inches long by three eighths wide. These are not rare.

Fig. 13 is a larger form of black basalt, triangular in outline, and with angular edges. It is three by one inches, and was found near Syracuse.

Fig. 14 is a handsome black and angular celt, with convex edges and somewhat rare form, three and seven eighths by one and seven

eighths inches wide, polished and from the Oneida River. Fig. 15 is also not a common form. It is nearly triangular and of light olive green slate, two and three fourths by one and one half inches. It is both thick and sharp, and has a very convex edge and comes from Seneca River.

Fig. 16 is much like one before described, and was found with it. It is of dark green striped slate, four and one half by two and one half inches, and is longer, narrower, and less twisted than the other. They are of moderate thickness, and no others have been reported at all resembling them.

Fig. 17 is a curious quartzite celt from the Mohawk River, being highly ornamented with lines and circular indentations, and having both sides thus carved. It is two and one quarter by one and one half inches. Celts are often thus ornamented, though not so profusely as this.

Fig. 18 is small, thin and symmetrical, with a cutting edge at each end. This feature is hardly rare, and appears in much larger specimens. This implement is but one and three fourths inches long by one half wide, the flat sides neatly curving to the sharp ends.

Fig. 18*a* is another very broad black celt of small size, one and three quarters by three quarters inches. Both are from Seneca River.

Fig. 19 is of grey sandstone with indented edges, and rather flat. It is five and one half inches long by two and one quarter broad, and was found at Onondaga Lake.

Fig. 20 is a beautiful and remarkable celt of green striped slate, from Onondaga Lake. It is quite broad, being two and one fourth by one and one half inches, and is remarkable for a depression across the surface half an inch from the edge, which has a flat grinding below this. It seems unique. Fig. 21 is grooved in a very different way, having three grooves across the back. It is thick and flat, of light olive green slate, and is five and one eighth by two and three eighths inches. It was found by the Oneida River, at Caughdenoy.

Fig. 22 is peculiar in many ways, having grooved lines lengthwise and across. It is four and one eighth by one inch, and comes

from the Thousand Islands. Fig. 23 is from the St. Lawrence River, and is one of the long and slender celts, widest in the center, flat on one side and curved on the other. The ends are rounded. It is of striped slate, six and seven eighths inches long, seven eighths wide and five eighths deep. Fig. 24 somewhat resembles this, but is more distinctly a double edged celt, being quite sharp at each end. One side is slightly but not conspicuously flattened, and a groove extends nearly around it. The other side is more rounded. It is of polished brown stone, three and three eighths inches long by one inch wide, and comes from Fleming, Cayuga County. Fig. 25 is of the same class, small and narrow, with curving sides. One surface is flat, the other raised, and while it is sharp only at one end, the other comes nearly to an edge. The form is wide spread but not common, and some specimens approach the boat stones in general outlines. They are usually of slate or fine sandstone. This one is from the Oneida River, and is two and three eighths by five eighths inches wide.

Fig. 26 is reduced in size with the nine which follow it. It is of a rare and peculiar celt, several of which have been found. They are very slender, usually nearly cylindric, and more or less pointed at each end. Sometimes the material seems too frail for use. This is one of the larger specimens, and 11½ inches long. The diameter is one by one and one fourth inches. It is angular and four sided, but the angles are rounded, and the points likewise. It tapers to each end, and shows no signs of use. The material is a polished dark gritty slate, from Seneca River.

Fig. 27 is another of the same general form, nine inches long by fifteen sixteenths thick. It is of a dark brownish steel grey, and is pointed at both ends. It was found near the Willard Asylum on Seneca Lake. This is of about the average length, but some are longer, and others more slender.

Fig. 28 seems an adze, and will be described under that head.

Fig. 29 is an unusual form of celt, contracting toward the point. It is made of green variegated slate, three and one half inches by one and one eighth wide, and is narrow and rounded at the cutting edge. It comes from Seneca River.

Fig. 30 might be classed as an adze. One surface is nearly a plane, and the other curves to each sharp end. It is of sandstone, nine and seven eighths inches long by one and three eighths deep, the width slightly exceeding the depth. It is from Brewerton, and a rare form for the size.

Fig. 31 is a small celt of variegated grey granite, from Van Buren. It is one and five eighths inches long by one and one eighth wide, and is quite flat on one side. Fig. 32 is larger and less angular, but of the same broad form. It is of a highly polished dark green marble, almost black, two and one eighth by two inches wide, and rather thick. The edges are rounded, and it comes from Seneca River. Fig. 33 is another of these small celts, made of black basalt and moderately broad. It is one and one half inches long by thirteen sixteenths wide, and comes from an early stockade on the Seneca River.

Fig. 34 is of black basalt, and is from a recent stockade in Pompey. It is an Onondaga implement used about A. D. 1630, and interesting in this way. It is thin, flat and angular, five and three eighths inches by two wide, and the edge is abruptly ground. It was found in 1878.

Fig. 35 is another of the small broad celts, from a place on the Seneca River where many of this form have been found. It is of basalt, one and three fourths inches by one and five eighths wide, the extreme width almost equaling the length.

Descriptions are added of a few celts not figured here, but all of which are described and illustrated elsewhere.

A fine angular and rather flat celt of black limestone is from Brewerton, and is nine inches long by two and three fourths wide. It has a fine polish and sharp angles, the latter being quite common with this form. Another, from the same place, is of black basalt, and almost triangular in section. It is quite large, being 11⅝ inches by two and three fourths wide. A fine angular celt of grey sandstone is also from Oneida Lake, and has a narrow back and sloping sides. Many of this peculiar form are found near there. This is five inches long by two and three eighths wide. Another of this frequent angular form is of basalt, and comes from the Seneca River.

It is three and three fourths inches long by one and three fourths wide.

A fine celt of light olive greenstone is from Skaneateles, and is seven inches long by one and five eighths wide, being narrow for its length. A long triangular celt from the Seneca River may have been an adze, and is much ridged on one side. It is eight and five eighths inches long by two and three fourths at the widest part.

One interesting example is of a celt of brown sandstone, the edge of which has been broken. At some distance from this the implement has been nearly half cut off, in order to form a new edge. The original length was five and five eighths by two and five eighths inches wide. It is from a much frequented site at Onondaga Lake.

Very many fine celts are of a mottled greenstone, and usually not angular, being of the general form of the first figure given. Two beautiful examples of these from the Seneca River are each five inches long by two and one quarter broad. This is a frequent form and size. One of dark greenstone, thin and flat, from Onondaga Lake, is perforated at one end, and like implements occur elsewhere. This article is four by one and one half inches, and all the edges are convex. Several double edged celts are from two and one half to four and one half inches long.

A grey quartzite celt, from Three River Point, has a slight roughened groove entirely around it, which is picked as well as the battered end. The size is eight by three inches. Of course this occasional groove or roughening was not needed in small celts. A curious one from the Oswego River has notches on the lateral edges like those of sinew stones, and reaching nearly the whole length. A perforation had also been commenced. The implement is four and five eighths by one and five eighths inches wide. Another from the same place is remarkable for having the date of 1700 upon it, as much weathered as any part. The edge is broken, and it tapers quite to the upper end. It is of ferruginous sandstone, five inches by two and one half wide. Another from the Seneca River has also transverse grooves on the edge. This feature is hardly rare. It is of a light grey and quite hard stone, three and seven eighths inches by two wide.

About half remains of a large celt found on the Seneca River, and made of polished greenstone. The fragment is now seven and one fourth inches long by three and five eighths broad, and is two inches thick. There are few New York celts as massive as this. One of the four sided angular celts from Oneida Lake is of light drab sandstone, and has the lower surface or back about half the width of the upper, which is a frequent proportion in these. It is nine and three eighths inches by two and seven eighths on this broad surface, and is correspondingly thick. Another from Brewerton has all the angles rectangular in section, and is about half as thick as wide. It is eight and one half inches by two and five eighths broad. One from Van Buren made of polished black basalt, nine and five eighths by two inches, has the upper side angular, and the lower side partly angular, partly rounded. Occasionally a celt is very broad, as is one of mottled greenstone from Onondaga, which is three and five eighths inches by two and three eighths broad. The general outline of this is a broad ellipse.

A frequent form, but of polished green slate, comes from Seneca Lake. It is almost pointed at the top, but moderately thin and generally rounded. It measures five and three fourths inches by two and one eighth wide. A larger angular one, from the same place, has the ends rounded, and one broad surface as usual. The sides are sloping and the back narrow. It is of grey slate, ten inches long by two and one half wide. An angular six sided celt from the Seneca River, is of a hard grey stone, five and one fourth inches long by two and one half broad. A broad celt of greenstone from Cayuga County, straight on one side and curved on the other, may be an adze. It has a central perforation, much enlarged on both sides. It is five and one half inches long by two and three eighths wide, and is one and one eighth thick. It is a rare form in every way. One of the narrow celts, flattened on one side and raised on the other, and suggestive of boat stones, comes from Binghamton. It is nearly sharp at both ends, and is four and three eighths inches long.

Several of the long cylindric celts have been found in various places, and among them is one of black slate from Schoharie

County. It is slightly angular, having a distinct edge on each side. One end is rounded, with a very narrow cutting edge at the other. It is nine inches long, with a maximum thickness of one inch. Another of brown sandstone, slightly flattened, is from Cayuga County. It is eight and three fourths inches by one and one fourth thick. The ends are rounded, terminating the tapering surface. Still another from Elbridge is very fine and slender, being now 11¾ long by one inch broad. It is of sandstone, and apparently about an inch has been newly broken from one end. It is circular in section, and tapers as usual, but seems unfitted for any use as an implement. All these are certainly very curious.

A large celt from Plattsburg has two knobs on the back, or rather projections. A large gouge from Oneida County has similar features. These may have been left for attaching a handle. The celt is quite angular and thick, and is nine inches long by two and one quarter wide. This feature is rare. The largest perfect celt brought to our attention is from Jefferson County. It is of greenstone, and is 13½ inches long by three and one fourth broad. Another large chipped one, from Plattsburg is 11 inches long by four and three eighths wide.

A fine angular celt of grey stone, from Three River Point, is quite thin, with one side flat and an expanding edge. It is four and three fourths inches long. A single celt of white marble has been found on the Seneca River. It is somewhat angular, and is four and one half inches long by two wide. Only one soapstone celt has met our eyes, and this came from the same river. Although angular, it is neatly rounded and finely polished, with an expanding edge. It is three and one half inches by one and one half broad. An article of soft red iron ore has the celt form for convenience merely, the grinding and cutting showing that it was used for paint.

One form, which is not frequent, is of a cream colored stone, very light in weight, first chipped and then finely polished. They occur mostly on the Seneca and Oswego Rivers. One from the former is four inches by two and one fourth broad, but they are usually narrower, forming a long ellipse. Another, a little differing from these, is from Oswego Falls, and made of a light chalky stone, 10¼

inches long by one and one half wide. It seems scarcely hard enough for much use, but the yellower ones are of a finer and harder grain, although so light in weight.

In Mr. A. E. Douglass' collection, out of 721 celts 85 are from New York, and about half of the smaller forms termed chisels. Dr. Abbott figures one New Jersey celt with a distinct groove, a frequent feature in New York, where all forms are abundant, some being local and unique.

GOUGES

Stone gouges are mostly found in the Atlantic States and are somewhat local there. They might be distinguished as the long gouges, tapering and evenly grooved from end to end; long gouges grooved part way; and broad gouges, distinguished in a similar manner. This would be but a broad classification. Long gouges have been found in Pennsylvania, although rare there. Dr. Abbott figured but one in New Jersey, where they are also rare. Two like his Fig. 140 have been found at Oneida Lake. In Saratoga County and vicinity, Mr. Wagman procured 29 gouges, the largest nine and one half by two and one half inches, and none of them were wider. He catalogued also adze gouges, probably meaning the broad forms.

Mr. Douglass has 85 gouges and adzes, of which 16 came from New York. Those in Central New York are mostly from Seneca River, Oneida, Onondaga, Skaneateles and Cross Lakes. They are most common near lakes and streams, and this makes it probable they were used in making canoes out of trees before bark was employed. They were unknown to the Iroquois. Out of 75 before us, more than one third are the long gouges, grooved from end to end, and tapering uniformly. Some are superb specimens.

Fig. 36 is a gouge of a beautiful light bluish striped slate, of unusual form and probably the finest known in this material. It is flat above and moderately rounded beneath, having a groove extending nearly half the length. The thickness is quite uniform throughout. It is seven and three eighths inches in length and two and one eighth wide, and was found near the Oneida River. It would hardly seem that it could have been employed in any common use.

Fig. 37 is a broad and flat gouge of brown hæmatite, from Van Buren. The broad depression is carried from end to end. Most of those of this form are of the same material, which is quite smooth but shows abundant pits with the polish. On this one an Indian and arrows have been marked with a fine point, doubtless by a much later hand. It is three and three fourths by two and one fourth inches wide, a common size.

Fig. 38 is a small gouge of the long variety, made of brown sandstone, three and three eighths by one and one half inches. It is from the north shore of Oneida Lake, and is grooved from end to end. Fig. 39 is also a small one, probably originally much like the last. It seems to have been broken, and then ground down to a celt-like edge, having part of the groove unchanged. Others occur where this has been done. This is of black basalt, and was found at Brewerton. The top is probably unaltered, and the present size is two and seven eighths inches by one and one fourth wide. For most purposes it is a gouge still. Fig. 40 presents the same feature, very little of the groove remaining. It is of grey sandstone, now flattened by this secondary work, and is four and five eighths by one and three fourths inches.

Fig. 42 is a very broad gouge from the vicinity of Oneida Lake, made of greenstone, and six and one fourth by two and one half inches. The broad groove is but two and one half inches long. Fig. 43 is much like this at one end, having a groove of similar outline. At the other end, however, the lines of another groove take a reverse sweep. Both ends are depressed. The material is greenstone, mottled with white, and the dimensions are four and three quarters by two inches. It was found near the Oswego River.

Fig. 45 is a fine long gouge of the usual size and form, from Oneida Lake. It is of black basalt, eight and one quarter by two and one quarter inches. Some others there were much larger. These long gouges are frequent, varying from four to ten and one half inches long, and they are always finely finished, but are not so common as the other forms. They occur throughout the St. Lawrence drainage in the East.

Fig. 54 is one of those we have termed long gouges, but it has a broad smooth groove across the back, not unique and yet a rare

feature. It is one of the finest examples of the kind, and is made of dark olive green slate, five by two inches. It was found on the Seneca River, west of Cross Lake. Fig. 55 has a somewhat similar dorsal groove, and is of ironstone, with a sharply ridged back, beveled down to the cutting edge. In section it is triangular, and the dimensions are four and one eighth by one and seven eighths inches. It was found near Cayuga Lake.

Fig. 61 is a broad gouge of rare form, closely resembling that of some celts. It is a handsome mottled stone four and one eighth by two and three eighths inches, and comes from the Oswego River. The back is ridged, and the central part of the upper surface at first slightly depressed, then quickly hollowed to the edge. Both ends are neatly rounded.

Fig. 72 is a reduced illustration of a curious implement combining the celt and gouge. The groove extends about half way from one end, while the other, which is broader, has a chisel edge. Toward the gouge end it is three eighths of an inch thick. It is picked and ground, and the dimensions are two and three fourths by one and three fourths inches. It comes from Seneca Lake.

An angular gouge of green gneiss from Jefferson County, has an angular groove, ending squarely at the upper end about midway in the implement. This is an unusual feature. It is six sided in section, nine and one eighth by one and three fourths inches wide, and is every way a remarkable article. Another large and curious gouge is from South Lake, Herkimer County. It is of black ironstone, and has a deep and long secondary groove in the center, with finer ones on either side of this. The length of the implement is 12¼ and the breadth two and one fourth inches.

Usually dorsal grooves are confined to the long gouges, but one from Brewerton, having the gouge cavity about one third of the length, has a broad and deep groove across the back, with a broad and shallow one above this. The back is somewhat flat, while the front is much curved. It is of light cream colored limestone, four and one quarter by two and three eighths inches wide. A long gouge from the same place is much contracted at the upper end, and is picked all over. It is of sandstone, six and seven eighths

by one and one half inches. A long gouge of black basalt from Skaneateles has a bulge in the back, but no dorsal groove. It was found in 1884 and is five and three eighths by two inches. Not far from this, in Spafford, a broad and thin ironstone gouge is three and seven eighths by two and one eighth inches.

A curious gouge of black basalt, from Oxford, has several knob-like protuberances on the back. The dimensions are seven and one half by two and three fourths inches. A long and deeply hollowed gouge from Oneida River, three and five eighths by one and five eighths inches, has two grooves across the back; and Pompey furnishes a long gouge of greenish grey stone, with the same feature. This implement is thick, but not of great length, the dimensions being four by one and seven eighths inches.

One beautiful long gouge from the Oneida River is of red slate, a very unusual material. It is seven and three fourths by two inches. One of black basalt from Cross Lake is both large and fine, being 10½ inches long and two and one half wide. Another of greenstone, from the Oswego River, is of a long tapering form, flat above. This is nine and three fourths by two and one half inches.

Broken gouges are frequently found. Fanciful uses have been ascribed to them, but it can hardly be doubted that they were employed in aboriginal carpentry, the shorter forms being often fitted to handles. In making the dug-out canoe they would have been very useful. The wide difference in material and form, however, suggests artisans of differing nations, but they were probably used only for a very limited time, as they certainly were confined to a moderate area. The makers have left so few traces that little can be conjectured regarding them. Only this we know, that they had no practical relationship to the later Indians.

ADZES AND HOES

Stone hoes and spades were but sparingly used in New York, as other materials were employed in the rude agriculture practised here by the aborigines. Loskiel says that the Delawares and Iroquois 'used formerly the shoulder blade of a deer or a tortoise shell, sharpened upon a stone and fastened to a thick stick, instead of a

hoe.' The Mohawks used wooden hoes. Corn, beans and squashes were the staple products, and rude implements sufficed for these. Some celts may have been adzes.

Fig. 28 is a curved celt-like implement of polished sandstone, from the east end of Oneida Lake.

The sharp end is almost pointed, while the other is rounded somewhat like a ball. This may have been used as a pick or a hoe. It is nine and one fourth inches long and one and three fourths thick, being reduced in the illustration.

Fig. 66 has been called an adze, spade or hoe and is a rare form in New York. It is of polished black slate, somewhat triangular in outline, and having a groove across the surface about a third of the way from the top. Below this is a large circular perforation. The size is four and one half by three and three quarters inches, and it is said to have been found near Canoga, on Cayuga Lake. It is a western form, and finely finished.

STONE BALLS

Stone balls were often employed by the Iroquois in the heads of war clubs, a hard knot sometimes serving the same purpose. Some Onondagas still preserve such stones used by their ancestors. They occur moderately on most Iroquois sites, whether early or recent, and generally show irregular facets, though sometimes quite globular. They are not usually large, but in one instance at least the size is too great for a war club. They are occasionally grooved, and many elliptical pebbles occur with this feature, which were probably sinkers, and had no relation to warfare. These are abundant on some lake shores, notably those of Cayuga and Seneca. In the West stone balls have been used by the Indians somewhat like slung shot, and they were well known as bolas in California and elsewhere. In New York the more elaborate stone balls may be considered recent. Although perforated stones have been said to have been used as weights for fire drills by the Iroquois, there is no proof of this in early days, as they do not occur on Iroquois sites; and a mistaken impression has been gathered from Morgan, who makes no mention of a stone in describing the fire drill.

Fig. 47 is a small, black and polished ball, out of a large quantity found together in an Indian cemetery at Dresden, on Seneca Lake. One of these is an inch in diameter, and another a little larger. They are not quite a perfect sphere. Fig. 53, from a stockade on the Seneca River, closely resembles these, and is an inch in general diameter, but is a little oblong. It is black and polished, and is quite heavy.

Fig. 49 is one of the larger balls, probably used in war clubs. It is of polished quartzite, naturally grey, but stained dark and with russet streaks. A distinct flattened zone encircles it one way, but is not conspicuous, and there are obscure facets. The diameter is about two and one eighth inches. This comes from the Onondaga town of 1696, near Jamesville. A large granite ball, one foot in diameter and worked all over, comes from the same place. It may have been used in games.

Fig. 51 is a ball of pink quartzite, faceted, picked and ground. There are four facets on opposite sides, and another begun. It is two and one half inches in diameter, and was found on a village site near Baldwinsville.

A polished brown sandstone ball was found near Amboy, which was covered with red paint, and was three and one fourth inches in diameter. A very irregular faceted one of brown sandstone is from Indian Hill, occupied by the Onondagas in 1654. It is two inches in diameter, and ground but not polished. One of picked ironstone was long in the possession of the Webster family, on the Onondaga Reservation. It is two and one fourth inches in diameter, and a little irregular. Many such balls are found in Cayuga County, where oblong grooved pebbles also occur. A large grooved ironstone ball, on the Onondaga Reservation, is unpolished, and three and seven eighths inches thick. A spherical one comes from Indian Hill.

Near Baldwinsville they are frequent on fortified sites, and elsewhere. One of light greenstone, from the double walled fort, has distinct facets, and is one and three quarters inches in diameter. Another, from the same place, is of light greenstone and has irregular facets. The diameter is two and one quarter inches, and it is

a little flattened. Many more might be described, but they present no very different features. The largest of these is three and three quarters by two and one quarter inches, and is of flesh colored granite.

Among the grooved pebbles is a long one, closely resembling one from Wyoming. It is grooved all around from end to end, the length being three and three quarters and the width one and three eighths inches. This is classed among the sinkers, which usually have the groove around the shorter circumference in New York.

A figure of a perforated ball of polished yellow granite was omitted from some doubt of its character. It was obtained near Cross Lake some years ago, and two and one eighth inches in diameter by one and five eighths inches. The perforation is countersunk at each end, the general diameter is a quarter of an inch, and it is neatly drilled. In 1897, however, Mr. A. G. Richmond received one of these from Otsego County, of which he says, 'This is a smooth stone, about two and one half inches long, one and three quarters in diameter, and with a hole lengthwise a quarter of an inch in diameter. It is something so unusual for this part of the country that I desire to call attention to it. It was a surface find in that county.' The two articles so closely correspond in size and character that they may be classed definitely among New York articles; the principal difference being that the first mentioned is drilled through the short diameter. Mr. Richmond would place them with the South American bolas, but the perforation of so hard a stone would suggest some other use. The figure is so simple as to be readily understood without illustration.

ORNAMENTS

For convenience in arranging illustrations, some of the small ornaments are not placed in consecutive order, but will be found at intervals among the rest. Early stone ornaments, aside from those classed as amulets, gorgets and ceremonial stones, were usually of slate, soapstone and sandstone, and were not many in number. Other things were more available and made more show. A little before A. D. 1700, catlinite, or red pipestone, was brought east in

small quantities, and soon became quite abundant. It assumed many forms, and was commonly delicately perforated for suspension, often having a double parallel perforation for the purpose of keeping it exactly in place. By this time the Indians had many steel tools, and handled them with native taste and skill, fashioning many simple ornaments for themselves. They became good gunsmiths, good silversmiths, and spared no time to make an article good. Plain circular ornaments, which were often but flat rings, were favorites, and these must have been laid out with compasses, which they had very early learned to use. Many articles were straight sided, and almost pyramidal in outline. Some pieces of stone were wrought into fishes, and others into human masks, often very small in size. Any ornamental form was useful, and some were derived from the whites. The gradual change in ornament is easily seen, particularly on the historic sites in the counties of Cayuga, Montgomery and Onondaga.

Fig. 5 is a characteristic example of the red pipestone ornament, nearly one and one half inches long and over three quarters wide at the base. It is less than a quarter of an inch wide at the narrow end, and there are small and shallow indentations all along the two longer edges, and on both sides. A double perforation extends from end to end, and is very small. This is from Oneida Lake. Fig. 41 is of the same material, and is of a dagger form, with a long groove on the face. It is a little over an inch in length, and comes from an Oneida site near Munnsville, in the vicinity of which the Oneidas long dwelt.

Fig. 44 is of an older and more curious article, from a site occupied by the Onondagas about A. D. 1600. It is a piece of sandstone almost square; in general appearance like the nut used with a screw. It is perforated like that, and is slightly convex on one side and concave on the other. One broad surface is grooved. The diameter is one inch.

Fig. 46 comprises figures of three stone beads, made of small drab colored concretions, from Chaumont in Jefferson County. Fig. 52 shows more from the same place. They are more commonly made from some perforated fossil, like the encrinite stems,

known in Scotland as St. Cuthbert's beads. Fig. 48 illustrates another and larger kind by two views. Natural concretions often become rude ornaments.

Fig. 50 is a heart-shaped ornament of sandstone from Oneida Lake, perforated near the top for suspension. Length seven eighths of an inch. Fig. 57 is a triangular ornament of red slate from Cayuga. The edges have a concave sweep, and it is less than an inch long. Fig. 56 is from the same vicinity, being a large pipestone ornament, with two perforations as in a gorget. It is rounded at the ends, and the sides are nearly parallel. It is flat and of moderate thickness, and the groove is parallel with the edge, except at one end. The length is three and one half and the breadth one and one quarter inches. Fig. 59 is of the same material and from the same county. It is a flat rectangle, with a circular central opening, and one perforation for stringing. Diameter a little over an inch. Fig. 60 is a flat truncated pyramid in outline, and from Onondaga County. It is perfectly plain, and has one longitudinal perforation. Length one and five eighths inches by one and one eighth wide.

Fig. 58 is a figured pendant of red slate from Cayuga. It is a circular disk, perforated for suspension at the edge, and adorned with irregular lines on each side. Carved disks and pebbles are usually recent. The diameter is one and one fourth inches. Fig. 82 is a flat ring of pipestone, one inch in diameter. These are common, as well as some of the forms already figured.

Fig. 84 is a long parallel sided article of light drab slate from Fish Creek, east of Oneida Lake. The ends are rounded, with a perforation near each. It is flat and polished, and the length is one and three fourths inches. Fig. 87 is a small four-pointed star of pipestone, with rounded ends. It was found at Oneida Lake, and is eleven sixteenths of an inch from point to point.

Fig. 88 is of three rude stone beads from Cayuga Lake. Two of these are flat, but the smallest is thick.

Fig. 126 is a small notched and polished pebble from a stockade site on Seneca River. The material is greenish slate, and except in size and finish is precisely like the flat notched sinkers. Long

diameter eleven sixteenths of an inch. Fig. 127 shows two from a recent Cayuga site, a very little longer, but otherwise like the last. The use is conjectural.

Fig. 138 is a straight sided but tapering flat ornament of pipestone from Cayuga. It is two and three sixteenths inches long, and very narrow. Fig. 148 is of the same material and from the same locality. It is a rectangular disk, with a central circular opening, and two small perforations; one on each side. Fig. 149 is another long pipestone ornament from Munnsville, with straight converging sides. Fig. 150 is rarer, but of the same material and from the same place. It is a small trefoil, showing a human figure on one surface. Length thirteen sixteenths of an inch.

Fig. 162 is a remarkable article from a much frequented early site on Onondaga Lake. It is a cup-shaped highly polished pendant of brown sandstone, perforated at the base for suspension. The inside distinctly shows the work of the rimming tool, but the outside has been carefully polished. It is nearly an inch in diameter, and seems unique here. A similar broken one has been found in California.

Fig. 181 is one of the pipestone ornaments with converging sides, but differs from most in rising to a ridge in the center of each surface. There is a central longitudinal perforation. This is also from Cayuga County. It is two and one eighth inches long by a little over an inch broad. Figs. 182 and 183 are small dagger-shaped ornaments of pipestone from Munnsville; the latter perforated for suspension. Fig. 190 is another Cayuga example of the flat pipestone ring, perforated as usual. Fig. 199 is similar, and this form is very common on recent sites.

Fig. 194 is a small pipestone ornament from Munnsville. The sides are curved, and the general appearance not unlike that of a Masonic level. Masonic silver emblems were common among the Indians a little later. Fig. 195, from the same place, is heart-shaped, and dots are disposed parallel with the margin. It is perforated at the lower point. Fig. 198 has the form of some small animal made of pipestone. This is from Cayuga.

Fig. 196 is a stone ring from the Oswego River, and is moderately symmetrical. The work is fair, but coarse. The projection on one side is perforated, and it may have been used for an earring or ornament. Stone finger rings are rare. Fig. 197 is another from Fort Plain, and on the seal are a tomahawk and arrow. These are recent of course.

Fig. 210 is a cylindric pipestone bead from Pompey. This form is rare. Fig. 225 is a curious perforated ornament of stone.

Fig. 226 is a pipestone mask from Wisconsin, which may be compared with New York specimens. Fig. 227 is a small pipestone mask from a recent site in Pompey. Fig. 228 is a rude pipestone mask, nearly square. This is from Munnsville. Fig. 232 is a small pipestone mask from Onondaga Lake. This has a rim above as though part of a pipe, but it is perforated for suspension. It is very finely worked. Fig. 233 is a small pipestone mask which lay on a child's skull in a grave at Scipioville. Another rather rude mask comes from Cayuga County. Fig. 238 is another fine mask from the same county. It is of grey marble, slightly concave behind, and is larger than most good examples here. Fig. 239 is a cobble stone on which is carved a human face. The character is modern and it comes from near Cape Vincent.

Fig. 229 is a quatrefoil of pipestone from Munnsville. It has a circular opening, and is a rare form of ornament.

Fig. 230 is a curious little pipestone ornament with volutes. It is from Munnsville and equally rare. Fig. 231 is a pipestone fish from the same place. Fig. 234 has straight but not parallel sides, and is of pipestone. Besides the grooved lines mostly parallel with the edges, there is inscribed on it the name of 'Joheannes,' in a very neat hand. It was found at Auriesville. Fig. 235 has also straight but not parallel sides. It is of pipestone and from Cayuga. There is a perforation midway in the narrow top, and one near each lower corner. A broad groove runs parallel with three edges, and within this are fine cross lines. It is two and five eighths long by one and five eighths inches wide.

Fig. 237 is also from Cayuga, and of pipestone. The straight sides converge, but the basal line is quite convex. There is a small

superficial perforation at the top and bottom. Fig. 240 is a small pipestone ornament found with a skeleton near Onondaga Lake. There are two perforations. Fig. 242 is a flat oval ornament of common slate, perforated at the small end, and found on an Onondaga site of 1600. Fig. 243 is a small pipestone ornament from Cayuga, with converging sides. It is notched along the edges and perforated. Fig. 244 is similar, but parallel sided, and comes from Pompey. Fig. 245 is a flat serpent form of soft greenish slate, and part of the back has been cracked off. A well defined head and scales remain, as well as the general outline. It is much curved horizontally, is three and seven eighths inches long, and probably very early.

A turtle totem of grey stone came from an early cache in Cayuga. It had projecting head, feet and tail, and was perforated for suspension. A frog of green slate, found in Canajoharie Creek, is well proportioned and carved, but seems recent. A disk of green sandstone from that vicinity has on it a tree, 1774, and W. H. K., and such inscriptions are not rare. A curious hatchet shaped stone found there, has a fine wolf's head in relief. A remarkable ornament is from Belleville, Jefferson County. It has on it what seems a ship, and also a fish with feet. It is of red slate, and much like other recent articles.

With all the vigor of their ornamental work it is commonly easy to distinguish that done by the aborigines from that of the white man, with a moderate experience, and quite as readily may recent work be distinguished from that which is earlier. Little touches make the difference. In some places there are scores of small pebbles adorned with designs, and probably made and used by Indians, but they are almost always recent work. On the great subject of these distinctions we need not enter now, merely calling attention to it.

HAMMER STONES AND MULLERS

Stones with pits or cups are found throughout the world, and much has been written on their uses. Many of them were undoubtedly hammer stones, specially when made of small pebbles, easily used in this way. Even these, however, are not alike, and other

uses have to be imagined. The larger flat stones, with many cavities, are plainly of a different class, but they are not frequent in New York, and require little attention now. They are quite generally considered nut stones, used for cracking hickory nuts specially, and it may be allowed that many had this occasional use at least. North and south alike the Indians made large use of nuts, and there was general rejoicing among the Senecas in 1670, because hickory nuts were so abundant. From these and from sunflowers they procured an oil which they highly prized. That they had suitable implements for cracking or crushing these there can be no doubt. To the wooden pestle and mortar the Mohawks sometimes added the crushing of grain between two stones, and this was more necessary when the harder nut-shell was to be cracked.

That these pits were used as sockets for fire-drills is against all probability. The proper socket for these was the dry wood, which could be set on fire as intended, while the stone could not. That some were used as lap stones is almost certain, and it is perfectly clear that many could not have been hammers. Some may have been used in games, so neatly are they finished, but the subject of their use will not be farther discussed now. The present conclusion is that they had varied uses, some of which are now unknown.

The ordinary hammer stones are too well known to require many illustrations, while, at the same time, there is an almost infinite variety of forms and combinations. A flat polished surface makes a muller; a deeply pitted surface marks many kinds of hammer stones. Those with battered edges probably had this use. Others of soft materials show no traces of this; some approach the southern chungke stone, and may have been used something like that. Hammer stones, so called, are still found on Iroquois sites, but two centuries old, and may have come down to the present century.

Fig. 62 is a circular pebble of brown sandstone, and seems to have been worked into shape. There is an irregular pit in the center on each side, and it never was used as a hammer, being too soft. The diameter is three and three eighths and the thickness one and one half inches. It is from a hamlet on the Seneca River.

Fig. 64 is a double muller. The ends are somewhat convex, as is often the case, and it is finely picked around the very deep edge. This is also from the Seneca River, where many forms abound. It is three and one half inches wide, and two and seven eighths deep. Both these figures are reduced. Fig. 122 is a muller of quite a different character. The last might have been used in a game, but this probably would not have been. It is of greenstone, and has the upper surface picked, polished and rounded, with a depression in the center. The edge is picked, so that it forms a true circle, while the under side is flat and polished. It is four inches wide by two deep.

A fine implement comes from the Seneca River, and is a circular flattened white sandstone pebble, neatly chipped around the edges, and broadly depressed on both sides, this depression nearly reaching the edge. The diameter is four and one half inches. Another is an elliptic pebble of brown sandstone, three and three quarters inches in the long diameter, and about half as thick. It is ground nearly flat on one side, as though for a muller, the remainder being left untouched. This is from Onondaga Lake. Another elliptical sandstone pebble has been roughly ground at one end, as though to change the shape, and an irregular groove has been sharply picked or cut in the center. Many show this primary picking, the depression being made for use, and not by use.

A broad central line of white quartz passes through a handsome angular black pebble, which has been roughly ground at one end, leaving it now a hammer stone, but it may have been intended for the ball of a war club. Many hammer stones have double pits on one or both surfaces of the elliptical or circular pebbles. One from a stockade on the Seneca River is an oval brown sandstone pebble, four and one quarter inches the long way. Sharp and moderately broad cuts have been made in this, in the center, with a sharp tool.

A curious stone comes from an Indian fireplace in East Varick. The Indian soon saw the advantages of compasses, and used them on shell and stone. This brown sandstone pebble has a slight pit in the center, from which six concentric circles were laid out, intersected by a six-pointed star. A recent double muller of grey

quartz, finely polished, is from Indian Hill (1654), and is so neat and symmetrical that it may have been intended for some game. The diameter is two and one eighth inches, and the thickness one and one eighth. It is a beautiful article. One fifty years older comes from a stockade some miles south of this. It is a red sandstone pebble, with both surfaces convexly ground, and with a small indentation. The edges are picked, and it is four inches wide by one and five eighths deep. A combined hammer stone and muller is from Indian Hill, but it has the pit in the center of the flat side. The convex side is depressed, and the edge hammered. A fine nut stone from Rome, nearly six inches across, has three cavities on one side, one of them of a lozenge form.

A curious elliptic pebble of brown sandstone is from Onondaga Lake. It is ground and pitted as usual, and from this a sloping surface has been ground toward each end. One from Cayuga County has terminal grooves instead. On Mohawk sites mullers are also found with European relics.

Fig. 76 is an extremely small muller, but three quarters of an inch across. It is a circular sandstone pebble distinctly ground on one side, and was found on the Seneca River.

PESTLES

Pestles are everywhere found, as might be expected, but were very sparingly used by the Iroquois, who preferred their wooden pestle and mortar, as they do still. The Jesuit missionaries among the Hurons expressed the same preference, although they had a hand mill which the Indians delighted to turn. The primitive implements gave the best results. Mr. Fowke thinks the cylindrical pestle was used as a rolling pin, but has taken no notice of the long flattened pebbles, so frequent in parts of New York. It may be they were sparingly used elsewhere. Stone mortars are more common toward the coast, and the ordinary pestle or pounder must often have been used without them. Prof. G. H. Perkins described a pestle with a carved head in Vermont, and there is one of these in the State Museum at Albany. Mr. Wagman had a fine one of this kind from Lake George, with an animal head at one end. It was 24 inches long and two thick. Several have been seen in the

central part of the State. Mr. Wagman had 23 long pestles, varying from seven to 21 inches long. They are quite as large elsewhere, but vary in form.

There are very many small ones, of long cylindric pebbles, more or less worked, which can hardly have been used in pounding, they are so light. They may have been employed for mixing paint, or for rolling pins. The short truncated forms are rare in New York, nor are the well worked cylinders common. Ruder implements often sufficed.

Fig. 63 is a grey sandstone pebble, seven inches long, and much enlarged at one end. It shows work and use, and was found at Onondaga Lake. This, with those up to Fig. 74 inclusive, are reduced in the illustrations. Fig. 65 is a small angular pestle of sandstone, flat and with parallel sides. It has been picked into shape, and the top is neatly rounded. It is three and three eighths inches long by one wide, and is from Seneca River, where these simple forms abound.

Fig. 67 is a well worked pestle from the vicinity of Rome, much contracted at one end for a little over an inch of the length, and then expanding to a thickness of two and one fourth inches. Hence the edges converge in straight lines toward the smaller rounded end. It is eight and three quarters inches long and angular. Near the broad end is a large pit like that of a hammer stone, which is a frequent feature of these angular pestles, whether broken or perfect.

Fig. 68 is the finest example known of the carved pestles, if it may be classed with them. In the illustration it is more reduced than the others, being drawn half their size. It is 15 inches long, and two and one half broad in the widest part of the handle, if it may be so called, for it seems more of a war club than pestle. It is a long pebble of a hard brown sandstone, and the tapering end, where it was grasped by the hand, shows much use. The sides are flat and neatly rounded at the edges, which are otherwise angular, the implement being about half as thick as wide. The head is boldly but neatly carved, representing an animal's head with conspicuous eyes and teeth. These are not in relief but engraved. Both sides are alike, and the head is somewhat thicker than the

broad handle, from which it is also distinguished at the neck. The eye has two circular perforations, separated by a ring between. A deep cut forms the mouth, and notches on either side of this are the teeth. Although somewhat heavy for a war club it would have been an effective weapon, and the sole signs of use are at the contracted end, farthest from the head. This being so it can hardly be doubted that it was a warlike weapon.

Fig. 69 is a broken sandstone pebble, having a carved head with a mouth and raised eyes or ears. It was found in 1879 at an early site on the Seneca River. One side is flat, and the work is rude. It now measures six and three quarters by one and three quarters inches. A fine example of the carved pestle is in the State Museum, having a fish's head. Several have occurred near the Seneca River which have now disappeared.

Fig. 70 is a fine cylindric pestle from the Seneca River, which has been picked and polished. The greatest width, two and one fourth inches, is just below the center, and it is nine and one half inches long. A larger one, which has lost part of its length, is from the same stream. It is of a long, tapering and cylindric form, polished, but retaining a few pick marks, and is of brown sandstone. It is still 14¼ long and one and five eighths inches thick at the small end where it was broken. The thicker end is two and one eighth inches in diameter.

Fig. 71 is very frequent form on the Seneca River, and though it shows use in pounding, it seems to have been oftener employed in grinding, one side and edge being flattened by use. It is a brown sandstone pebble, and was found at Onondaga Lake. The length is eight and three eighths inches, and it is quite slender, the width being one and three quarters, with a thickness of one and one eighth inches.

Fig. 73 is a cylindric and truncated pestle of brown sandstone, which is perfect, and is five and one fourth by two and one fourth inches. Another of similar form is also from the Seneca River, and of a little larger dimensions. Fig. 74 is a truncated pebble, picked at both ends, and comes from the same stream. It is a cylindric sandstone, two and one half inches long by one and three quarters

thick. Dr. Abbott considered these hammers, but hammering and pounding are much alike.

Fig. 75 is a pyriform grey sandstone pestle from Onondaga Lake. It resembles a plummet, but is larger and not grooved. These would not be real distinctions, but while this implement has been picked and polished, the ends have been battered by use. It is four and one eighth by two and one fourth inches.

Fig. 89 is a good example of the small pestles probably used in preparing paint. It is of brown sandstone and quite slender, being four and five eighths by one and three eighths inches. It has slight pits, and is from the Oneida River. There are many like this, but usually larger.

Many large and rude pestles occur. One of brown sandstone, from Elbridge, is slightly spoon-shaped, having a small wedge-like projection at one end, useful for cleaving off bark, and this may have been its purpose. Except this it is rectangular in section, and has the sides nearly parallel. It is 24 inches long, with a general thickness of two and one half inches. Another similar and of the same material, comes from the same town. It is almost square in section, and quite straight like the last. The length is 17 inches, and it is two and one half by two and one quarter inches in thickness. These large and rude implements often occur in various places, and quite a number from Brewerton are full 18 inches long.

A curious but rude pestle of brown sandstone comes from the Seneca River. It is quite angular, and four of the sides are smooth. Between these the edges are roughly chamfered. One smooth side is grooved like a gouge at the smaller end, probably in sharpening tools, and there are pits at the larger end. It is eight and one fourth inches long, the greatest width being one and seven eighths inches. A flat sandstone pestle, from Oneida Creek, has parallel sides and compressed ends, with many pits. The dimensions are six and three eighths by two and five eighths inches.

One from Onondaga Lake has one edge perfectly straight, while the other is picked and curved, and has a transverse groove, perhaps for attaching a handle. Both ends show use. This is seven and seven eighths by two and seven eighths inches. A somewhat

cylindric but six-sided pestle is from Oneida Lake. The size is 19¼ by two and one fourth inches. This is a rude article, but a well wrought cylindric pestle, 11¼ by two and three eighths inches is from the same place. A flattened one of sandstone, from Oswego Falls, is 14⅞ by two and one half inches.

A pestle from Oswego Falls resembles Fig. 67. It is square in section and compressed at the larger end, whence it tapers to the smaller. The form is long and slender, being 18 inches in length by two and seven eighths thick. A pyriform pestle of grey sandstone is from Cross Lake, and is ground in lines toward one end. The length is three and one fourth and the thickness one and one half inches.

Though the Iroquois used stone pestles but little, one of the sandstone pebbles utilized as pestles on the Seneca River and elsewhere so freely, has been found on Indian Hill. It is 10⅜ inches long, perfectly straight most of the way on one side, and showing marks of human use. A cylindrical pestle of sandstone comes from Rome, and is nine inches long by two and one half thick. From the same place is another, compressed near the broad end and with pits on two sides. It tapers as usual, and is flattened. The ends are hammered. It is six inches long by two inches in diameter.

A large pestle with a carved head has been described, found on the Hudson below Albany. The eyes are sunken and the lips lined. The length is 26 and the diameter one and seven eighths inches. One cylindric pestle is from Seneca Lake, and is made of sandstone. It is nine and three quarters inches long and two and five eighths thick.

Quite curious forms occur in Tioga County. A massive squared one from Newark Valley is reported as being 15 inches long and five and one half thick, while other curious ones occur in the neighborhood. One from Owego, broadly shouldered below the handle, is 17½ inches long, six and one half broad at the base and four and one fourth thick. The shoulder is 10 inches above the base, and the weight 21 pounds. A similar one from the same place is 15 inches long and four inches in the greatest diameter. The handle is cylindric, the base being square, and eight inches long.

Fig. 85 is a curious little implement of fine brown sandstone, from the Seneca River. Although so small its form suggests a pestle, but it was probably a paint muller, as it is more adapted for grinding than any other use. It is rectangular both in section and outline, and is one and three eighths inches long, with a long diameter of three quarters of an inch. Both ends are flat, and might be used for grinding.

POTSTONE

Fragments of potstone vessels are found in many parts of the State, but perfect vessels are now very rare. The material was so easily worked that it was used for other things. Naturally the remains of vessels occur oftenest near navigable waters, as they were too heavy to carry far by hand. Among those in the Wagman collection was one with a handle, and such handles are usually more or less carved. The vessels are most neatly finished within, as a rule, and are often quite shallow. Outside, the base is often left rough and angular, perhaps that it may stand the better, or for finishing in leisure hours. The material was not procured in the State, although it occurs here, and probably most of the vessels come from Pennsylvania. Dr. Abbott mentioned none in New Jersey, nor have any been reported in Canada, where steatite pipes are common. Many fragments are perforated, and some have been worked over for new uses.

Fig. 77 is a section of a vessel restored from fragments found at Rome. The pieces were saved, put together, and this is a reduced figure of the vessel, which is 10 inches high and about 20 inches across the handles. The greatest thickness at the bottom is one and one half inches, and this is quite flat, although rounding quickly to the sides. The rim is thin, and this is a common feature. Many vessels are much shallower than this. One from the Oswego River is angular at the bottom, and the total outside depth in places is but two inches, the bottom being three eighths of an inch thick and perfectly flat. The curving rim of this is notched. Another, from the Seneca River, is also shallow, broader at the base than at the top outside, and nearly straight at top and bottom; the bottom diameter being four and three eighths inches. The inner side is nicely curved, and the fragment is perforated in one place. It may be that a better

finish was in prospect for the outside, which is quite rude. The broad handle projects one and one fourth inches, and has five straight grooves on the upper side, at right angles to the vessel. Straight rims, however, are often found.

Fig. 78 is a curious piece of potstone, somewhat like a door knob. It seems complete, and is neatly finished, but has no assignable use. When worked all over, however, steatite might seem finished in any stage. It comes from Onondaga Lake, and is two inches long, one and one half wide, and one deep.

Fig. 79 shows a notched potstone rim, and this form is frequent. Some rims have simply acute notches, while in other fragments they have a rounded form. The perforations are well known. Many fragments are curiously grooved, and one has two grooved edges and two perforations. It is now three and one fourth by two and three fourths inches across.

Fig. 80 is a potstone sinker, made from the curving side of a broken vessel. Grooves encompass it near each end. This is two and three eighths by one and one eighth inches, and one much like it has been found at Owego. The one figured is from the Seneca River.

Fig. 81 is a handsome notched and grooved handle, with part of the notched rim. The projection and width are each one and one half inches. This is a frequent size of handles. Fig. 83 is another broader and heavier handle, being from a heavy vessel found by the Seneca River, and then entire. It was left exposed, broken by frost, and carried off in fragments. If circular it would have been 13½ inches in diameter at the rim. The under side of the handle is smooth, and blackened with use. The upper is adorned with cross grooves. The projection is two and one fourth inches. Several carved handles might be described, and they project from one to three inches or more, with a corresponding width. In the Rome example, the projection is one and one fourth, with a width of two and three fourth inches.

STONE PLUMMETS

A very interesting class of stone implements is that of the plummets, which are somewhat local in New York. They have a very

moderate distribution here, but probably Brewerton, at the foot of Oneida Lake, has furnished more than all the State beside. Even there they mostly occur in a very limited area. They are not rare about Onondaga Lake, and these are the two localities of Central New York. Local specimens differ much from those of the West. It has been surmised that they had a superstitious use, but here they seem confined to good fishing places, and may well be classed as sinkers, although some of them seem hardly fitted for this use.

There are many plummets in the South, having the usual groove but also often perforated. They occur in New England, Ohio, and California. Out of 270 in his collection, Mr. Douglass had but 29 from New York. It would be interesting to know from what points these came. None have been reported from New Jersey. Dr. Abbott says that one was found in a mortar in Massachusetts, and Schoolcraft not only speaks of them in New Hampshire, but says that the Pennacook Indians used them as sinkers. The latter statement may be taken for what it is worth. The Eskimo have similar sinkers, but they are perforated. Among the California Indians it is said they were used as rain charms, and rude ones are found in the Florida shell mounds.

Fig. 3 is a small and slender, as well as rather flat slate plummet or pendant, slightly resembling the older ones. It is rather an ornament than anything else, and comes from a recent site in Pompey. It is placed here because of a likeness which is more apparent than real. The length is two inches.

Fig. 90 is a slender curved one, not of the usual form, but grooved in a frequent way. Near each end is an encircling groove to which a cord might have been attached. Across each rounded end is a connecting groove, often seen at the top of plummets. It is of dark sandstone and was found in Elbridge. The length is four and one half, and the thickness one and one eighth inches. A similar curved one of brown sandstone, from the Seneca River, is much flatter, and has tally notches on each side. This is three and seven eighths inches long, and one and five eighths broad the widest way.

Fig. 91 is a true plummet of fine polished grey sandstone, from Onondaga Lake, beautifully worked and of fine form. The groove

is unusually near the top. It is four and one fourth long by nearly one and one half inches thick. Fig. 92 is of flattened red sandstone, with a pointed eight-sided top above the groove. The body is also angular and rather irregular. This came from the Seneca River, between the lakes mentioned, and is three and five eighths long by one and one half inches wide.

Fig. 93 is of greenstone, generally cylindrical and slightly faceted. The groove is deep and the top simple. This, with several following, came from Brewerton. It is three and one half long by one and one half inches wide. Fig. 94 is very broad, and is polished and somewhat flattened. It is elliptic in section, and made of red granite. It has shoulders but no groove, and is two long by one and three quarters inches broad. A few closely resemble this. Fig. 95 is also shouldered, but without a groove, and is made of hornblendic gneiss. It is two and one half long by one and one eighth inches wide. Fig. 96 is of greenstone, has a square head, and is generally angular, with but slight curves. It is three inches long by one and three eighths wide.

Fig. 133 is of brown sandstone pyriform, and with a deep groove. It is two and five sixteenths inches long by one and three eighths broad. Fig. 134 has no groove, but one has been commenced. It is of quartz and four-sided, but with the angles rounded. It is two and one half inches long and one and one quarter broad. Fig. 216 is reduced in the illustration, and is of a flattened and angular green basalt, one and thirteen sixteenths inches long by one inch thick.

A faceted greenstone, two and three fourths by one and one fourth inches, has a small projection above the groove at the top. A few are very slender. One of polished brown slate from Catskill is of this kind. The outline is a long pointed ellipse. It is three and seven eighths long by seven eighths of an inch in diameter. Not unlike this, but with rounded ends is one of grey sandstone, from Brewerton. It is also less slender, being three and three quarters by one and one eighth inches. Many are ovoid and grooved, but angular forms are common. One of these, from the Onondaga Reservation, is eight-sided, the alternate faces being wide and narrow. It is of light brown sandstone, three by one and

one eighth inches. One of green talc, two and three fourths by one and one half inches, has many facets. This also is from Brewerton.

Angular forms are often thickest in the center. Quite a proportion have a cross groove over the end above the circular notch. A very irregular one of sandstone has about thirty facets, but this is unusual, and such a feature may be only preparatory to a finer finish.

SINEW STONES

Though the name of sinew stones may not exactly express the use of a familiar class of articles, it yet answers a purpose, the grooves being supposed to come from drawing sinews across the stone. The best examples are thus of rather soft sandstone, easily worn. The theory imagines this operation for making an even bow-string, not an unlikely thing. Dr. Abbott described one of these stones, and said they had never been figured before. They are not common, and yet have a wide distribution.

Fig. 86 is unusually fine, having many of these grooves deeply impressed in this brown sandstone pebble, and the other side is like the one shown. This is from Binghamton, and three and seven eighths inches long, which is about the usual size. A larger one from Oneida Lake, has grooves and notches, and is five and one half by two inches. Another, from Cayuga Lake, is almost triangular, and has deep grooves all around. This is three and one half by two and one quarter inches. A brown sandstone pebble from Seneca County, three and one half by two and three quarters inches, has grooves only at one end. These, of course, increase in number and depth through use. One, from Onondaga Lake, has deep grooves, and is three and one half inches long. One of grey sandstone, from Schoharie County, has similar grooves, and is four and one fourth inches in length. A much larger one of grey sandstone, from Oswego Falls, has but slight grooves, being a hard stone. Several come from Brewerton, but this enumeration will show their distribution and leading features. The drawing of thread through beeswax will illustrate their appearance and possible mode of formation. The general form, of course, will be that of the pebble, and the marks will vary with use.

STONE PIPES

Both clay and stone pipes are rare in New Jersey, and these are inferior to those of New York, where so many of the finest examples of both are found. Equally fine are those of Canada, where they are common. At first the Iroquois made clay pipes only, but afterwards used European tools on those of stone. The early and recent pipes are easily distinguished as a rule, but space will not allow a discussion of this, although a few early notes may be given.

In describing the Indians of New England in 1643, Roger Williams said, 'Sometimes they make such great pipes, both of wood and stone, that they are too foot long, with men and beasts carved, so big or massie, that a man may be hurt mortally by one of them, but these commonly come from the Mauguawogs, or the men eaters, three or four hundred miles from us. They have an excellent art to cast their pewter and brasse into very neat and artificial pipes'. These pewter, brass and iron pipes are still sometimes found, but the Mohawks made pipes of clay at the time to which he refers.

In the *Jesuit Relation* of 1653, is the account of a conference between a New England nation and the French. The ambassador 'seats himself in the midst of the place; he takes two great petunoirs, made of a green stone, beautiful and highly polished, a cubit long. This was the fifth present. He fills one of them with tobacco, puts fire to it, and sucks or draws the smoke out of it very gravely. All the assembly watched him, not knowing what he meant. After having well smoked at his ease; "My brother," said he "these two pipes, or these two petunoirs, are yours; it is necessary henceforth that we have but one breath and one respiration, since we now have but one soul".' These petunoirs may have been stone tubes, pipes sometimes taking this form, as they did in California, nor are straight pipes unknown here.

In his account of the southern Indians, Adair said, 'They make beautiful stone pipes; and the Cheerake the best of any of the Indians, for their mountainous country contains many different sorts and colors of soils proper for such uses. They easily form them with their knives; the pipes being of a very soft quality till they are

smoked in and used to fire, when they become quite hard. They are often a full span long, and the bowls are about half as large again as those of our English pipes. The forepart of each commonly runs out with a sharp peak, two or three fingers broad, and a quarter of an inch thick. On both sides of the bowl they cut several pictures, with a great deal of skill and labor.'

In his early account of the Narragansetts, Wood says, 'From hence other tribes have their great stone pipes, which will hold a quarter of an ounce of tobacco, which they make with steel drills and other instruments; such is their ingenuity and dexterity that they can imitate the English mold so accurately that were it not for matter and color it were hard to distinguish them; they make these of green, and sometimes of black stone.'

Capt. John Smith described the stone pipes, apparently, of the Sasquesahanocks, although they were of the Huron Iroquois family, which then used mainly clay pipes. In describing one of these gigantic men, he spoke of 'his tobacco pipe, three quarters of a yard long, prettily carved with a bird or beare, a deare or some such device at the great end, sufficient to beat out the brains of a man.'

In 1756 Sir William Johnson presented a great calumet to the Six Nations, and said, 'Take this pipe to your great council chamber at Onondaga. Let it hang there in view, and should you be wavering in your minds at any time, take and smoke out of it, and think of my advice given with it, and you will recover and think properly.' Gives the largest pipe in America, made on purpose. They replied, 'We assure you we shall hang it up in our council chamber, and make proper use of it upon all occasions.' This great pipe was used at the conference with Pontiac at Oswego, in July, 1766. Pontiac's pipe was lighted and handed around, and afterwards 'the Onondaga speaker lighted a calumet of peace, which Sir William left in their hands many years ago, for their use, and handed it about to the western Indians.' This probably disappeared in the Revolutionary war.

In his account of the conference between De la Barre and the Onondagas in 1684, La Hontan described the pipe of peace, and perhaps had in mind the one then used. The council assembled,

and he gives a plan of this. 'The Grangula sat on the east side, being placed at the head of his men, with his pipe in his mouth, and the great calumet of peace before him.' Then follows an account of the official pipe. 'The calumet or pipe, is made of certain stones, or of marble, whether red, black or white. The pipe or stalk is four or five feet long; the body of the calumet is eight inches long; and the mouth or head, in which the tobacco is lodged, is three inches in length; its figure approaches that of a hammer. The red calumets are most esteemed. The calumet is trimmed with yellow, white and green feathers.' He gave a small figure, both of the pipe and speaker, but little can be gathered from them. His description is general, and as he afterwards traveled in the West, it may have been made from western pipes. About this time, however, the red pipestone came into New York.

Mr. Douglass' collection has 43 New York pipes in a total of 375, but it is evident that they once existed here in great numbers. Besides those made by the Indians large quantities of pipe clay pipes were distributed at councils and treaties by the English, and these antique articles are frequent on the more recent sites. Certain forms of stone pipes are found throughout the Northern States, made within the last two centuries, and those of pipestone are confessedly modern. At present a very simple article suffices for the Indian's need in New York.

Fig. 97 is a remarkable pipe of black soapstone, with inlaid eyes of hollow bone. This fine pipe was found in a grave on the Seneca River, and with it were European articles. The handle beneath is a characteristic of part of the pipes of the historic period, and appears in much simpler forms. When this is found the age may be thus determined in a general way. The bowl is capacious, and the face very fine and expressive. This is turned away from the smoker, another feature of the later pipes, whether of clay or stone. It is four and one half inches high. A head-dress slightly appears, but not such as might have been expected.

Fig. 98 is of yellow sandstone, and was found in Cayuga county. The form of the bowl is both early and recent, and has animals in relief on the sides. It is one and seven eighths inches high. Fig.

99 is a short platform pipe, the bowl being much narrower the other way. Many of these platform pipes are of recent date, the earlier ones often having a curving base. This is from Onondaga Lake, and is one and seven eighths inches long by one and one fourth deep.

Fig. 100 is a black marble pipe from Jamesville, near the site where the Onondaga fort was burned in 1696. The situation, however, does not necessarily indicate its age, nor have we any certain guide to this. All examples of this form have the figure or face, where there is either, toward the smoker, which was an early fashion; otherwise the pipe would seem recent. This has a full length of a man, rudely carved, on the back of the bowl, and the zigzag ornament at the top has a modern look. The lines enclosing the figure, and the raised rim above it, appear in clay pipes made three centuries ago, and this is probably one of the earliest pipes made for or by the Iroquois with metallic tools. The extreme length is four and three fourths inches, about the average size of this form, which frequently occurs. There is, however, an Indian pipe, resembling this form but without the elevated projection and figure, which belonged to Tim Murphy, the noted rifleman and ranger of the Revolution, and which has his initials upon it. It is a little more angular, and is three and one fourth inches long by one and one fourth high. This is not far from the dimensions of some of these. These things suggest a modern date, strengthened by the localities where most of such pipes have been found.

One of these of a burnt sienna color, with a face on the back and a moulding at the top, has the same general character. It is from Baldwinsville, and is two and three quarters inches long. One of soapstone, four inches long, has an elevation like the Jamesville pipe, and is from the Oneida River. Another of the same character, from the Seneca river, is of white marble, and the extreme length is three and three fourths inches. Another with a human figure on the back is from Schodack. It is of yellow soapstone, and is larger than most of this kind. A white one from Root, Montgomery County, has a human figure, and is three and three fourths inches long. Two, with human faces and figures, come from Jefferson

County. Others might be described, and among these, those with two raised heads.

Fig. 101 is of white marble, and has the short stem nearly at a right angle with the bowl. The angles and bowl are rounded, and the latter is chiseled within. This is from Wayne County, and is two and three eighths inches high. Fig. 102 is a stemless pipe bowl of dark soapstone, one and seven eighths inches high. It is curved and polished, and the rim has deep curves between the two raised points. It is a rare form, and comes from the Seneca River.

Fig. 103 is a bird pipe of dark green slate, from the Oneida River. It is moderately thick, and there is a perforated projection in front, to which ornaments may have been attached. It has wings and feathers, a cockscomb, and an engraved collar or necklace, as well as a thick open bill. The form and work are modern. One much like this, but ruder, is in the Canadian collection at Toronto. This has a simpler crest, thicker bill, and less detail than the New York pipe, and is but four and one fourth inches high, while the former is seven and one half inches.

Fig. 104 is a flat turtle pipe of yellowish grey stone from the Oswego River. It is two and one half by two and one fourth inches across, and but seven eighths of an inch high. This form occurs elsewhere, both in New York and Canada, and might be called a platform pipe. Fig. 105 is a very rude and low soapstone platform pipe, from the east end of Oneida Lake. It is one and three quarters by one and one half inches. Fig. 106 is a black marble pipe from the Seneca River. It is perfectly plain, but otherwise much like some already described. From tip to tip it is three and three eighths inches.

Fig. 107 is almost globular, and of grey quartzite. There is a groove around the center, and radiating cuts at the top. The height is two and one quarter inches, and it comes from Van Buren. Fig. 108 is a small black and broken pipe from Canandaigua, much contracted between the low bowl and swollen base. It is not quite one and one half inches high, and is from a recent site. It seems an imitation of some European forms. Fig. 109 is a long platform pipe, perhaps made by the Cherokees. The platform is perforated at the

extreme front, and the bowl is angular. It is five and one eighth inches long and two and one quarter high, and comes from the east end of Oneida Lake. Fig. 110 resembles modern western forms, but is of grey stone. It tapers to a curving point in front, and is three and one half long by two inches high.

Fig. 111 is a double stone pipe, found near Nichols Pond in Madison County, but probably having no relations to it. It is formed like a keg, with a bowl at each end, and stem holes sloping different ways. It is of brown sandstone, two inches high by one and three fourths thick. Fig. 112 is of sienna colored marble, elliptic in longitudinal section, contracted and grooved a third of the way from the top. The base has a projection with a perforation. Height two and one quarter inches. It is a recent form, and comes from Brewerton. A similar one, contracted but not grooved, comes from Cross Lake. It has a large orifice, a basal perforation, and is two and three fourths inches high.

Fig. 113 is a double faced bird pipe, two and one half inches deep, from Monroe County. It is a recent form, with basal fluting and projection. Fig. 114 is a dark stone pipe from Pompey. Like all with this platform and basal projection, it is a recent form. The height is three and one half inches. Fig. 115 is a very different style of platform pipe, from the Seneca River. The extreme length is three and three fourths inches, and the stem hole is at the short end. It is quite thin, and is made of a crystalline stone.

Fig. 116 is from the Seneca Castle of 1779 at Geneva, and is sometimes called the bottle stopper pattern. It has a pointed and perforated base, and is two and three fourths high by one and one fourth inches thick. It is a recent form, of course. Another much like it, comes from the same place. Another is from Canoga, the birth place of Red Jacket, and is a little smaller. Another is from Onondaga Lake, and many more might be mentioned, all with perforated bases, which is a modern feature. It is one of the most frequent and recent of our stone pipes.

Fig. 117 is another bird pipe, similar to Fig. 103, and a rare form. It seems to have been made by the same hand, and was found on the Seneca River. The same style of work appears in some Ohio

pipes, and in one figured by Dr. Rau from New York. This pipe is of green slate, and not thick, and has a perforated projection in front, as well as lines and grooves for feathers. The extreme length is three and three fourths inches.

Fig. 118 is a steatite pipe with a projecting rim on either side ot the stem. The same form occurs in clay in Cayuga, where this feature is quite common on clay pipes of various forms. This was found with these, and is a rare form in any material. Except for the flanges it is a tapering cylinder, slightly bent. It is three and three quarters long by one inch in diameter at the top of the bowl.

Fig. 119 is an ovoid pipe from Onondaga, made of greylimestone, and two inches high. The form is rather rare in New York, and may be called a southern form. Fig. 120 is a slender black pipe from Seneca Falls, two and three fourths inches long, and having the stem at a very broad angle with the bowl. Fig. 151 is a straight and somewhat flattened pipe of dark green soapstone. Though others approach this it may be considered unique. It is from Brewerton, and is three inches long, by one and one eighth thick. Fig. 152 is similar but not so straight, and has flanges on each side below the bowl, which is more distinct than in the last. It belongs to the Onondaga Historical Association, and probably is from that county. It is of green sandstone, and is three and three quarters inches long. Such straight pipes are everywhere rare. Another of green soapstone comes from the east shore of Cayuga Lake, and this has a narrow projection on one side below the bowl.

Fig. 153 is a common form in clay, but rare in stone, being often called the trumpet form. It has a curved stem, broadening into the circular bowl, and the latter has moldings and beaded grooves. It is three and five eighths inches long, and was found west of Cross Lake. Its interest is in the material.

Platform pipes sometimes have a slight ornamentation of a simple kind. A fine one from Cross Lake has an oblong bowl at one end, and lines on the top of the platform. The stem hole, as in some other cases, is at the short end of the platform, leaving the longer projection beyond the bowl. The height is one and seven eighths inches. One of brown marble has moldings around the

top, and a zigzag ornament on the narrow edge of the stem. The platform of this comes to a point at the short end. The height is two and one eighth inches. Another of soapstone from the east end of Oneida Lake, has the bowl close to the end of the long platform. It is three and one half long by one and one half inches high. There are many varieties of the platform pipe, and they reach the Hudson at least.

One simple but graceful pipe is from Jefferson County, and bears some resemblance to some before figured, but is more slender. It contracts below the top of the circular bowl, and then gradually expands toward the rounded base. It is less than two inches high. Most of the stone pipes from that county are recent forms, the early inhabitants, probably the ancestors of the Onondagas, having used those of clay. Of these there are fine examples. One curious pipe of mottled green soapstone, comes from that county. The raised end of the bowl, which is at the back as usual in this form, is divided into two broad horns, on each of which is a human face of modern type. It was probably made in the seventeenth century. Each projection is divided into two concentric horns above the face, terminating in a point. In these respects it is unique.

TUBES

Five classes of tubes are enumerated by Mr. Fowke, in the Reports of the Bureau of Ethnology, four of which are represented in New York. To these may be added here those with four flattened sides, which do not essentially differ from the cylindric forms; and those with an expanding end, generally almost closed. The use of all these articles is conjectural, and may not have been always the same. One well supported theory is that they were used in sucking blood when bleeding was resorted to, or in injecting the smoke of medicinal plants. In California they have bone mouth pieces, and are usually classed as pipes. Schoolcraft gave the first account of these in 1843, and those he examined from a Grave Creek mound are like those found in New York and on the east shore of Lake Champlain. His account is not readily accessible, and may therefore be quoted.

'Several polished tubes of stone have been found in one of the lesser mounds, the use of which is not apparent. One of these, now on my table, is 12 inches long, one and one fourth wide at one end, and one and one half at the other. It is made of a compact lead blue steatite, mottled, and has been constructed by boring, in the manner of a gun barrel. This boring is continued to within about three eighths of an inch of the larger end, through which but a small aperture is left. If this small aperture be looked through, objects at a distance are more clearly seen. Whether it had this telescopic use or others, the degree of art evinced in its construction is far from rude. By inserting a wooden rod and valve this tube would be converted into a powerful siphon or syringe.'

For a time these were called telescopic tubes, and it will be observed that the description is like that of those found at Otisco Lake, Palatine Bridge and Lake Champlain, which differ much from the ordinary stone tubes. Those found on the east shore of Lake Champlain, by Prof. George H. Perkins, were from seven to 13 inches long, the perforation being about an inch in general diameter, contracting to half an inch at one end, which had a small perforation, closed by a stone plug. Others have been found on that lake, but these plugs are not elsewhere reported.

The material of tubes in general is soft, and often ornamental. Some are gouged out, and some drilled, and the outline varies greatly. The long ones, with one end expanded, and with a small central perforation in this, connecting it with the usually uniform perforation just within, are of quite soft material. Those from Otisco Lake were either filled or in contact with red paint. This class of tubes embraces those much longer than the ordinary forms, and they are more slender than the long ones of California. Some forms are drilled from both ends, and this may be the case with the larger part. They do not seem to reach the Atlantic coast, but one of oolitic limestone was found at Deming's Point, Dutchess County, which was broken at one end. It is now five and three fourths inches long, an inch in diameter at the perfect end, and one and one eighth at the other.

While it is conceded that the California tubes were pipes, their use in the East is not yet determined. They were made and used by early nations, not the later comers, probably, among whom, how-

ever, bone tubes may have supplied their place. Small bone tubes are found on Iroquois sites, but may have been used for ornaments. Among the Onondagas long tubular bone or cane whistles were employed in medicine making, even within a few years.

Fig. 122 is a tube of dark green striped slate, generally rectangular in section, but with the broader sides somewhat convex and the narrower concave. It comes from the Oswego River, and is of a slightly tapering form. The perforation is usually smaller at one end than the other, and in this case is three eighths by nine sixteenths of an inch. It is three and one half long by one and one fourth inches wide.

Fig. 123 is a cylindric tube of grey striped slate from Camillus, five and five eighths inches long by one inch in diameter. This is the usual form. Fig. 124 is of light olive green slate, a little over three and one fourth inches long, and comes from the town of Van Buren. The orifice is half an inch at one end, and five eighths of an inch in diameter at the other. It is not quite elliptic in section, being flattened on one side. This was found in 1846, and is a rare form. Fig. 125 is a cylindric, tapering tube, of a very beautiful striped green slate, with interrupted bands. It is seven inches long, and was found in Palermo, Oswego County. It is thickest toward one end.

Fig. 128 is a long sandstone tube, apparently, but Mr. S. L. Frey thought it might be steatite on microscopic examination. It is one of several found in graves at Palatine Bridge. The orifice at the small end is over five eighths of an inch wide, and the diameter of the tube there is one inch. The general diameter is about one and one eighth inches, and the length nine and one half, being reduced in the illustration. The perforation is quite uniform until near the broad end, where the outside of the tube suddenly expands, and has a small central perforation in the end. Another is longer. A similar one, belonging to Mr. A. G. Richmond, is 10 inches long, but a little narrower than the one described. It was found in the same cemetery. The graves were quite remarkable, and contained other relics. Fig. 129 is one of a different form, found at the same place, but not in the same grave. The outline is undulating, much like

some wooden handles, and the perforation gradually contracts, showing an important difference in the mode of drilling. The size is four and one half long by one and one fourth inches in diameter. The illustration is reduced.

Fig. 130 is a large and angular tube of soapstone, much curved, and with a raised band in the central part. It is eight and one half inches long, and is from Allegany County. The same form occurs in Tennessee, but is rare.

Three of a greenish white and soft slate were found in a grave by Otisco Lake some years since. They are in fragments, all of which were not saved, and are of the same general character as the first described from Palatine Bridge. The expanded end is one and three eighths inches in diameter, and the general thickness is one and one eighth inches, thus closely corresponding in size. Full accounts of those at Palatine Bridge and Swanton have been published in the *American Naturalist*, and some particulars regarding the Otisco tubes may be of interest. They were unearthed many years ago, in digging foundations for a barn on the east side of Otisco Lake, and were thrown into a soap box with other things, some of which were taken away from time to time. Two skeletons lay side by side with them, well preserved; also arrow points, and lumps of red and white paint. They were about two feet under ground, and the skeletons had their heads to the west. Among the fragments left are two perforated end pieces, and the size of other pieces indicates at least three tubes. Being broken the circular lines of the boring within are plainly seen, and the perforation rapidly contracts near the small hole by a series of four or five circular ridges. Some of the fragments are stained within and without with red paint, but probably did not contain this. The graves were on Mr. Van Benthuysen's farm north of Amber.

One of reddish grey sandstone, found east of the Seneca River in 1841, and therefore one of the earliest brought to light, was described by the owner as a stone faucet, which it resembles. It is tapering, and thickest near the center. The length is six and one eighth inches, and the diameter one and one half in the thickest part. The orifice is three fourths and five eighths of an inch.

Occasionally one is found unfinished, like a regularly cylindric one from Jefferson County, which is six and three fourths inches long, and not polished. The hole is one and three fourths inches deep, and seems to have been drilled with flint, as it tapers to a point. A cylindric one of striped olive slate is from Onondaga, and is eight and three eighths long by one and one eighth inches thick. Another of green striped slate is from Cayuga County, one side being flat and the rest convex. The orifice is unusually small; not over a quarter of an inch. It is three inches long by one and one half thick. A curved tube comes from Chaumont, and is three and one half long by one and one fourth inches broad. Other tubes have also been found in Jefferson County.

One from Saratoga is three and one half by two and one half inches, an unusual proportion here. A cylindric one of striped slate from Brewerton, is four and three fourths by one and one half inches. A very long one of green striped slate, from near Albany, is 11 inches long, if correctly reported. This would be an unusual size in this material.

Some tubes are very small, and a cylindric one of striped olive slate, from Seneca Lake is two and one half inches by less than one. An unfinished tube from Cross Lake is four by one and five eighths inches. The boring is uniform to the depth of one and five eighths inches, showing circular grooves. It is of picked greenstone.

Out of 73 tubes Mr. Douglass had none from New York.

BAYONET SLATES

For want of a better this term is applied to a small class of rare implements, probably of a ceremonial kind. Very few have been found. They are slender, and nearly or quite parallel sided and triangular in section. One found in Vermont is seven and one eighth by one and one eighth inches, and has no shouldered base. Another has been found in Canada closely resembling this in form and size. Two others come from Onondaga County, and are probably the finest known, as they seem to complete the list.

Fig. 131 is a very fine example of this rare article, and the largest yet found. It is reduced for illustration, but is eight and seven

eighths inches long by seven eighths of an inch wide. The broad surface is flat, the other two forming a ridge at their junction, making the implement triangular in section. There is a slight tapering toward the point, which is formed by a quick curving of the edges. The base is a little contracted, and depressed on the upper side, with slight notches for attaching it to a handle. The material is bluish striped slate, and it was found near Brewerton on the Oneida River.

Fig. 132 is also reduced, and is of a similar article a little wider and much shorter; the length being four and seven eighths inches. The base is shorter and more contracted than the last, and the point not as quickly curved. This is also of striped slate. It was found near Brewerton, and also on low land.

The two just described came from low ground, and are somewhat discolored in this way, specially on one surface. They are as finely polished as other implements of striped slate, and in excellent preservation. No signs of use appear upon them, and they may have had little more than an ornamental character.

AMULETS

Bird and bar amulets are very rare south of Ohio, nor are the latter frequent anywhere. One of the former has been found in Virginia, one in Pennsylvania, and one in New Jersey. The latter one has projecting ears, and is four and one half inches long. They reach Wisconsin on the west, and occur sparingly in New England.

The theories about their use seem fanciful, as some certainly are. Two writers assert that they were worn by married or pregnant women only, and many have accepted this statement. Others think they were worn by conjurers, or fixed on the prows of canoes. It is enough to say that some of the perforations are not adapted to any of these uses. It seems better to class them with the war and prey or hunting gods of the Zunis, some of which they resemble. In that case, the holes, of whatever kind, would have given a firm hold to the thongs which bound the arrows to the amulet, a matter of importance in an irregular figure.

These perforations form the most important feature. The amulet may be but a simple bar, but at each end of the base is a sloping hole, bored from the end and base and meeting. To this necessary feature may be added a simple head or tail, and there may also be projecting ears. None of these are essential. They are but appropriate or tasteful accessories.

Two notable collections contain a large number of amulets. In the Canadian collection at Toronto there are about fifty bird amulets from the province of Ontario, and many of these are much depressed. The longest is six and three eighths inches. Besides these there is a score of bar amulets, a very much rarer form. The longest is six and one quarter inches. They are mostly of striped slate.

The collection of Mr. A. E. Douglass is larger, having 70 bird amulets; 35 of which are from Ohio, and 16 from New York. One of the latter, from near Auburn, has a turtle-shaped head. His collection contains the unusually large number of 38 bar amulets, 22 of which are from Ohio, and but one from New York. The latter seem quite rare here, not more than half a dozen having come before us. Bird amulets are much more frequent, upwards of 50 having been shown us in various places, besides those mentioned above.

They were variable in material as well as form, although most commonly made of striped slate. Perhaps full half have projecting ears, when of the bird form. In the wider forms, usually of harder materials, there are often cross bars on the under side, in which the perforations are made. Occasionally these are not entirely enclosed, yet are without signs of breakage. This seems to prove that these were not intended as a means of attaching them to any larger object, on which they would rest, but rather for fastening articles upon them, as in the Zuni amulets already mentioned, and which were illustrated by Mr. Frank H. Cushing, in the second Report of the Bureau of Ethnology. On comparison a general resemblance to these will be seen, and in a few cases it is quite striking. That they were used in this way, rather than in those suggested by others, is a reasonable conclusion which gains strength with fuller study.

As a class they belong to the St. Lawrence basin and the region of the great lakes, but seem most abundant north and south of Lake Erie. In New York they are most frequent for a few miles south of Lake Ontario, specially near the Seneca River and the larger lakes connected with it. They are found on Lake Champlain also, several coming from the vicinity of Plattsburg. Two came from Washington County, one of which has an expanded body and prominent ears, and is made of slate. Usually this material is confined to the narrower forms. This one is four inches long and one and one half high. The other, of the same material, is of a different form, and shorter and higher. The dimensions are three and one half by two inches.

Fig. 135 is a remarkably fine bird amulet of green striped slate, the longest we have seen from New York, but reduced in the illustration. It is nine and seven eighths inches from tip to tip, and of moderate height and thickness. It was found at Dexter, near the mouth of the Black River, and although in three pieces was not otherwise defaced. The back is sharp, and it has projecting ears and a long neck. The head ends squarely. Another, from the same county, is also large, being eight and five eighths inches long by two high. It has no projecting ears.

Fig. 136 is from Dresden, on Seneca Lake, and is of green striped slate. The ears are unusually small. It is a fine article, and is three and one half long by one and one half inches high. Fig. 137 is of the same material, but is much depressed. The sloping tail expands to three inches in width. This is from Jefferson County, and the length is six and one eighth inches.

Fig. 139 is also of green striped slate, from the Seneca River, and is three and one fourth inches in length. There are no ears, but along the edges are 91 notches. This feature often appears, but not to this extent. Fig. 140 is of trap rock, and comes from Clinton County. It is rude, depressed, and has small ears. The general form is quite straight, but the tail is slightly raised. It is more suggestive of the Zuni amulets than most forms. The dimensions are six and seven eighths long by one and one half inches high.

Fig. 141 is a broad form of mottled stone, three and three eighths long by one and three fourths inches high. It comes from Newark

Valley, Tioga County. There are small projecting ears and the tail comes to a point, as in some others of this general form and material. Two views are given of it. This form is highly polished, and the basal perforations are not always completely enclosed. They have also, as a rule, a slight transverse ridge, in which the perforation is made.

Fig. 142 is from Elbridge, and of green striped slate. It is quite depressed, and the tail is but one inch high, the length being four and one half inches. The large ears have but a small projection, and the general form is narrow. Fig. 143 is from Cayuga County, and is of the same material. It is somewhat depressed, and has a very long and pointed head. The dimensions are five by one and three fourths inches high. Many from that vicinity are depressed.

Fig. 144 comes from near the Seneca River, and is of the same slate. It is three and three eighths long by one and three eighths inches high, and has no ears. Fig. 145 is from Brewerton, where many have been found. It is quite thick and heavy, making a strong contrast with the last. The material is a grey striped slate, and the ears are small. It is five and five eighths inches long.

Fig. 146 is a very curious and fine bird amulet from the Seneca River, four and one half inches long by one and three fourths wide, made of a mottled dark stone, grey and yellow, hard and highly polished. The ears project to an unusual extent, and the forward perforation is not entirely closed. It closely resembles one from Grand Rapids, Michigan, in form and material, but has a more expanded tail. In fact it may be considered the finest example of this class of amulets yet found.

A few others may be briefly described, without illustrations. One of green striped slate, from Baldwinsville, has no ears, and is four and one fourth long by one and three fourths inches high, which is about the average size. The tail varies much in angle and height, in the several specimens, and the head is as variable in form and length.

One of brown striped slate, found a few miles south of the Seneca River, has no ears and is much depressed. It is five inches long and two and one fourth high. Another of brown slate, from Cayuga

County, and which is broken, has a lateral perforation, a frequent feature for a secondary use of ornamental stones, allowing them to be suspended as decorations. The edges are also notched, a frequent feature of amulets, perhaps as a record. The remaining part of this is three inches long. One from the Onondaga Reservation was worn as a decoration by an Indian girl, being suspended by a string passed through the secondary lateral perforation. This amulet is of green slate, and has been broken, having lost the bill or nose. It is still four and one fourth inches long by one and seven eighths high.

A fine one from the Oswego River, of green striped slate, is of unusual form. The ears are elliptic, slightly raised but not stemmed, and there is a shallow groove in each. It is three and one fourth long by one and one fourth inches high. Another, of the same slate, was found south of the Seneca River, and has projecting ears. This is four and one half long by one and one half inches high. Still another, of this material, is from St. Lawrence County, and is one and three fourths inches high by three and one fourth long. It is quite high for its length, and the tail is upright, which is not a rare feature. One of light green slate, from the Seneca River, is quite thin, and had small projecting ears, one of which has disappeared. The tail is low, and the amulet is five inches long by one and three fourths high. Many broken amulets might be described, and some have interesting peculiarities. One of grey slate, from Cayuga County, has a lateral perforation and an unusually long neck. A water worn one, from the beach of Cayuga Lake, has a rounded tail, and a groove across the base.

It will be seen that the bar amulets are few in comparison with the others, but they were apparently all used in the same way. All have the terminal basal perforations, and usually they are slightly raised in the center and at the ends. Fig. 147 represents the typical form. This is of dark green striped slate, and was found on the Seneca River. This is five and seven eighths inches long and three fourths of an inch wide and high. It is slightly elevated and thickened at the center and ends. Of course there is nothing specially

ornamental in this, but it might readily be used as the Zuni amulets were.

Another, almost exactly like this, was found at Onondaga Lake, but is a little longer. Still another of striped slate, very uniform in thickness throughout, was found on the Oneida River in 1879. It had lain for centuries in low land, and was much discolored. The length was five and one fourth inches, and the width and depth one inch each. One from Wayne County is of dark green slate, and has small notches or tally marks along the edges. It has a flattened top, which may have been a curving ridge at first, and is five and one eighth inches long by three quarters of an inch high. A broken one, of the same material, comes from Brewerton, and another, of brownish slate, was found near the Willard Asylum on Seneca Lake. This is four inches long.

BOAT STONES

Mr. Fowke classes the boat stones as a division of the banner stones, sometimes calling them gorgets; neither of which do they much resemble. They are not always perforated, though this may have been the ultimate intention. When this has been done there are usually two holes, bored from the same side. Banner stones have commonly but one hole, which is large, central, and quite uniform. Gorgets may have several, and each one is usually drilled from both sides. The banner stones might have been used on a staff, whether they were or not. No such use could have been made either of boat stone or gorget. Very often, however, fine examples of the former are not perforated, and have little in common with the other implements mentioned.

Few true boat stones, if by this is to be understood those which have been excavated, are to be found in New York. The excavation, however, may be merely a device to make the stone lighter, rather than an essential feature. If this is allowed, as seems reasonable, many might be placed under this head.

Fig. 154 is one of these, four and one eighth inches long, and seven eighths of an inch high. It is a little over an inch in width, and a lateral section gives a long triangle, the deepest part being near one end. Before and behind this are perforations from top

to bottom, of unequal diameter, but each broadest at the base. The material is striped slate, and it was found on the east side of Cayuga Lake.

Fig. 155 has a slightly curved base, with a convex sweep; the upper surface having a much greater convexity. A groove is carried through the base, hollowing it as in the true boat stones. It is of green slate, striped, and has two holes; these, as in other cases, being drilled from the lower side, and are broad on that surface and small above. This was found on the east side of Onondaga Lake, and is three and three fourths inches long, one and one eighth wide, and three fourths of an inch high. The outline of this and the last, from above, is very nearly a parallelogram.

Fig. 156 has a broad broken end, which has been smoothed, and this is perforated somewhat like the amulets; a terminal hole intersecting that bored from base to top. The other end resembles the tails of bird amulets, but is unperforated. Another hole, however, goes from base to ridge, being intersected by a lateral basal groove. Both this groove and the terminal perforation, of course, are secondary. On what was the central apex is a small nipple, frequently found in this class of articles. The perfect end has slight notches, and the material is brown slate. The present length is three and one eighth inches, and it is one and one eighth in height. This interesting example of original design and secondary work is from the Oswego River.

Fig. 157 is of green striped slate, five and one half inches long and one and three eighths high. It was found north of Cross Lake, and has the two customary perforations, one before and one behind the central and prominent nipple. It is a fine example of this form. Some smaller Ohio specimens have quite a pyramidal outline, and the nipple is like a small ball.

Fig. 158 is of the same slate, and somewhat like a low pyramid, but the opposite sides do not quite meet at the top. It is four and one fourth inches long, one and one half wide, and one and one fourth high. This has neither perforation nor excavation, and is from the Seneca River.

Fig. 165 may be simply a long perforated sinker, of light greenish slate, but the terminal perforations suggest both the bar amulets and the perforated boat stones, to neither of which does it belong. There is a slight groove toward one end, and depressions around the holes. The general section would be three-sided. It comes from the Seneca River.

Fig. 214 is unperforated, nor has it a nipple. It expands greatly in the center, where it is over one and one fourth inches wide, while the terminal widths are much less than an inch. It is five and one eighth inches long, and seven eighths of an inch high in the center. The material is brown slate, and it comes from Hannibal. An unfinished one of granite, almost pyramidal and six and one half inches long, is from Oswego Falls. Several come from Cayuga County, and one from Troy has two perforations, and is five and one eighth inches long and one inch high. A fine one of dark olive slate, with nearly straight base and convex upper surface, comes from Canajoharie. There are two perforations from the base, which is also grooved. It is five and one eighth inches long, one and one fourth high, and one and one eighth wide. One of slate, from Tioga County, has a straight base and a rounded upper surface. It is three and one fourth inches long, and has two perforations, the specific number.

True boat stones occur throughout the northern States, and many good examples are found in Ohio. New York has probably as many forms as any. They are found along Lake Champlain, and at several places on the Hudson River, as well as in the localities already mentioned.

CUPS AND MORTARS

Small cups are occasionally found, probably used for holding paint, and usually having one side elevated. Mortars are often but depressions in bowlders or rocks, and these are found in all parts of New York, though most frequent near tidal waters. Some of those thus classed, however, are simply hollows made in sharpening tools. Of this character is one on Indian Hill, the Onondaga site of 1654. Several polished depressions will be found in a large bowlder there. Mortars, however, were often portable. One from

near Syracuse is of calcareous tufa, seven inches in outside depth, and four and one half inside. The upper diameters are 11 and 11½, with a diameter of eight inches at the bottom. This has been called a mortar, but is properly a vessel of another kind. One from Kendaia is a nearly circular pebble, seven and one half inches across, and excavated on both sides. A fine circular one is from Pompey Center, of limestone, and much like the last. It is nine inches in diameter, and the depression is six inches across. Many of these might be described.

Fig. 159 is a beautiful cup of dark bluish green striped slate, two and three fourths inches across. It was found in Hannibal in 1875, and is unique here, but one has since been added to the Toronto collection, closely resembling this in every way. The form is circular, and the shallow bowl is neatly curved to a point at the base. These two examples add to the other proofs of the close relations of New York and Canada in prehistoric times.

Most cups are of ruder form, and they are rarely symmetrical. Fig. 160 is one of these, and is of soapstone, with one side raised. It is two and five eighths inches across the long diameter, and comes from the Oneida River, with one of similar form. Fig. 163 is a small one found in or near an earthwork in Elbridge, and made of brown sandstone. It is one and one fourth inches wide, and one side is deeper than the other. A paint dish or bowl, four and one fourth inches wide and two deep, comes from the Mohawk River. A small stone ball was in it. There are other examples, but of no special importance.

DOUBLE-EDGED SLATE KNIVES

A class of polished slate knives in New York and part of Canada, has long had the local name of slate arrows, and these are but little known to archæologists in general. They closely resemble but are not generally identical with some of the slate knives of the Point Barrow Eskimo, figured and described in the ninth Report of the Bureau of Ethnology. Those figured in that volume have no barbs, and these are a common but not invariable feature of these New York knives. The grinding and provisions for hafting are identical.

There are suggestive similarities between several Iroquois articles

and those of the Eskimo, but these slate knives were apparently used here long before the Iroquois entered New York. The half circular slate knives of Canada, New York and the Eastern States, also raise the question of early visits of the Eskimo, and the probability of these is strengthened by the recent finding of articles made of walrus tusks, south of Lake Ontario. They occur also in Canada, and near the St. Lawrence. Without discussing this question at length, it may suffice to say that these two forms of knives are in present use among the Eskimo, and that that people lived on the north shores of the Gulf of St. Lawrence 300 years ago, whence, at a still earlier day, it would have been easy for them to make hunting excursions into New York by water. Certain it is that south of New York one of these articles has never been found, and the other but rarely.

In some parts of Canada the knives now to be considered are about as common as in New York, being most abundant on both sides of Lake Ontario. They have not been reported east of Lake Champlain, except in its immediate vicinity, with the exception of one in Maine, nor do they reach more than half way southward to the Pennsylvania line. In fact here they are rarely found far away from the larger lakes and streams tributary to the St. Lawrence.

Fig. 161 is a dark grey slate knife of this kind, and one of a frequent form, being shouldered but having no barbs. There are slight notches on either side of the tang. It is two and three eighths inches long, and not quite one and one fourth wide. Fig. 164 is another of grey slate, two and one fourth long by one and one fourth inches wide. This is broadly shouldered, and approaches the barbed form. The base is of unusual dimensions, being half the length. Both of these are from the Seneca River.

Fig. 166 is very long, and with nearly parallel sides. The base is broken, but it is still five and five eighths inches long by one and one fourth wide. It has barbs and distinct notches, and is reported from Chenango County, an unusual location. Fig. 167 is of grey slate, with long barbs and very deep notches, which are like sharp teeth. It is three and three fourths inches long and one and three

eighths broad. From the Seneca River. Fig. 168 is a small and deeply notched knife, of unusual form, one and five eighths inches long. It is of dark grey slate, and was found at Brewerton. Fig. 169 is of dark slate, and is from the Oneida River. In its present form it closely resembles some of the Eskimo knives, but it probably once had barbs which have been cut away. It is two and one half inches long by one broad. Occasionally one seems to have been broken and recut, leaving it unsymmetrical but strikingly like some recent Eskimo knives.

Fig. 170 is of red slate, shouldered, short and very broad. It is from Jefferson County, and one and five eighths inches long by one and one eighth wide. The notches are deep. Those of red slate are often quite broad. They occur mostly on Lake Champlain, but some are found south of Lake Ontario.

Fig. 171 is of bluish slate, from the Seneca River, and has barbs. It is two and three eighths inches long and one and one fourth wide. This is a frequent form. Fig. 172 is of dark slate, from Chittenango Creek, near Oneida Lake, and is three by one and three eighths inches. Instead of coming to a more or less defined medial ridge, it is sharply beveled from a plane surface to the edges. It is shouldered, and the base has no lateral notches. Fig. 173 is the smallest yet found, and is of grey slate, and one and one fourth inches long by a little over half an inch broad. It is shouldered and rather rude. This was found at Onondaga Lake. Fig. 174 is omitted.

Fig. 175 is of dark slate, somewhat barbed, and conspicuously notched on the edges of the base. It is ground from the center to the edges, like most others, and is three and three fourths inches long by one and three eighths wide. This is from the Seneca River. Fig. 176 is the handsomest yet found, and is from an island in the Oneida River at Brewerton, where broken harpoons, as well as perfect ones, have been abundant. It is of grey slate, shouldered and thin, finely polished, and with an unusually slender base and deep notches. The base is finely finished and rounded. This fine knife is two and seven eighths inches long by one and one eighth wide.

But a few typical specimens are figured, but these knives vary much in proportions and details. The barbs are usually formed by cutting a groove between the cutting edge and tang, and the notches may be simply cuts or half circular grooves. The surface is usually ground all over, and all is polished except the flattened tang, which is often slightly roughened by a coarser grinding. In Eskimo knives this is inserted in a handle, and the New York specimens are usually beveled for this purpose. A few others may be mentioned.

One of greenish slate, from Baldwinsville, is one and three fourths long by one and one fourth inches wide, and is barbed and notched. A similar one is of the same dimensions. A slender one of dark slate is barbed, but has the base broken. It is four and three fourths inches long by one and one half wide. A curious one of red slate is very broad. It is broken, but was originally three and one fourth long by two and one fourth inches broad. It may have been a little longer, but the edges have more than the usual convex sweep. All these are from the same place.

Another broken one, from the same locality, is of dark slate, shouldered, and without lateral notches. The present size is three and one fourth by one and one half inches, and it was once a fine implement. One which is barbed and has a convex edge, is flat in the center, instead of having the usual ridge. It is two and three fourths by one and one half inches. Another fine one of grey slate, also from the Seneca River, has a very sharp point, and is seven and one half by one and one fourth inches, an unusual size.

A small one of grey slate, from the Oswego River, is barbed, and has both blade and base very tapering. It is two inches by one. A long one of grey slate, from Baldwinsville, is also barbed, and is four and one half by one and three eighths inches. A handsome one of brown slate is from the same place, and is shouldered. The surface is rounded and not distinctly ridged. It is three and one eighth inches long by one and one fourth broad.

A shouldered one of black slate, from the Oswego River, is three and one fourth inches long by one and one fourth wide. One from Onondaga Lake is barbed and has the sharp end neatly

rounded, instead of coming to a point. This part differs little from the rest of the work, but if it was the original design it is certainly unique. It was probably repointed at an early or recent day. It is of dark slate, two and one half by one and one fourth inches. One of dark slate, from the Seneca River, has very deep notches, and is one and three fourths long by one and one eighth inches wide. Another of green slate, from the same river, has the same features, and is three by one and three eighths inches. Quite a number of grey slate come from the Oswego River. A fine one of this material, from the Seneca River, is shouldered, but has no grooves or lateral notches. It is three and one eighth inches long by one and one fourth wide, which is about the average size. Another of red slate is from the same place, and is broken, but is two and one eighth inches wide, and was proportionately long; probably about six inches. The base is short and the notches deep. This is barbed.

A barbed one, with a very long stem, comes from Oswego Falls. Another, of dark slate and shouldered, is from Chittenango Creek, and is three by one and five eighths inches. Another long-stemmed knife of grey slate is from Brewerton, and is two and three eighths by one and three eighths inches. The barbs are long and the notches distant, A large black one comes from Cayuga County, and several from Jefferson. These are not far from three inches in length. A large black one is from Rome, where others have been found. A broken one of black slate is from Kendaia, east of Seneca Lake, the extreme southern limit of these articles thus far. The width is one and three eighths and the present length three inches. Several come from that lake, as would be natural from its connection with the Oswego river. A fine barbed one of brown slate, having deep notches, is from Seneca County, and is three and one eighth by one and one fourth inches. Another black and barbed one, which has lost its base, is from the same vicinity. The present size is four and one fourth by one and five eighths inches.

One from near Holland Patent now represents the eastern range of these in the interior of New York. It is barbed, of grey slate and is four and one half by one and five eighths inches. Another of grey slate, from Brewerton, has unusually long and prominent barbs, as

well as deep notches. It is two and three eighths by one and three eighths inches. Another from that vicinity, of black slate, is smooth and thick. It is shouldered but there are suggestions of barbs, and the base is nearly half the length. It is three and one eighth inches long by one and one half wide. In all about 100 have been figured and described in New York, and a smaller number in Canada. Of New York specimens two thirds come from a territory of forty miles square, and always near water. This is significant of their use.

THE WOMAN'S KNIFE

Much better known than the double edged slate knife is the semi-circular one, known as the Ulu, or woman's knife of the Eskimo, and still in use by that people. In the interesting examples figured by Prof. Otis T. Mason and others, will be found those of metal and slate, which closely resemble those of stone found in our fields, shown also with handles attached. Ours, however, are never perforated, nor is the curved outline interrupted before reaching the back, thus answering to but a division of these interesting implements. Dr. Abbott has well said, 'As these semi-lunar knives are more abundant in New England than in the Middle States, and do not appear to have been in use among the southern coast tribes, it is probable that the pattern is derived from the Eskimo, with whom the Northern Algonkins were frequently in contact.' Dr. Rau endorsed this view.

Since these eminent scientists published this opinion many of these implements have been found in New York, perhaps more than in all the New England States, and the features of their distribution point to their use by northern visitors, rather than by settled inhabitants. They are far from rare on both sides of Lake Ontario, but most frequent toward the eastern end, the part most accessible to the Eskimo. Very rarely they have been found in New Jersey and Pennsylvania, and are oftenest near fishing resorts. They were unknown to the Iroquois.

They are all essentially of the same form, the principal difference being in having a simple or a thickened back, so that a very few

figures will fairly illustrate this class of implements, though some others may be described.

Fig. 177 is of a slaty sandstone, and has an unusually deep thickened back, the blade being quite thin. The edge has been broken, and this and the grinding required to keep it sharp, have interfered with the perfect curve. It was found west of Cross Lake, and is two and one fourth inches deep by two and seven eighths wide. These thickened backs are comparatively rare. Fig. 178 is quite unique, being of a black and very hard slate, which is very thick in comparison with others. The ends have been broken, and the back is rounded. It comes from the Seneca River, and its present size is three inches wide by one and one eighth deep.

Fig. 179 has lost about a third of its width which was originally five and one half inches, with a depth of two inches. It is of brown sandstone, with a deep and thick back. This is from the Seneca River. Fig. 180 comes from near Oneida Lake, and has no thickening of the nearly straight back. It is of grey sandstone, and forms nearly a half circle, two and one fourth by six and one eighth inches. A few others may be described.

One from near the Seneca River is of thin red slate, with a simple back, and is nearly a true half circle, being two by five inches. It is quite sharp and symmetrical. Another, from the Oneida River, is also of red slate, two and one half by six inches. One of dark slate, from Camden, has a less convex edge and an irregular back. It is six and one half by two inches. One of red slate, from Oswego County, broken, and now three by five inches, seems to have been originally nine and one fourth by three and one fourth inches. Another, from the same county, and of the same material, has an irregular back, and is six inches wide by one and three quarters deep. A very fine one of red slate, found on the Oneida River, is perfect, and is six and seven eighths by three inches, with a thickness of a quarter of an inch.

Several come from near Lake Champlain. One of these, of mottled slate, is six and one half by two and one eighth inches. A perfect one of dark slate is six by two inches; and another, which has a thick back, is five inches wide by two and three fourths deep.

Many come from near Brewerton and Oneida Lake. One of these is of brown banded slate, and has an irregular back. It is slightly broken, and was originally six by two inches. Another is of brown sandstone, and has a simple back neatly rounded on both edges. It is a little over one and one fourth inches deep, but was originally seven and three eighths wide. One of grey sandstone is five and three fourths by two and one eighth inches. Another of green slate is a true half circle, being five by two and one half inches. It has a straight back, and a similar one has a thickened back. Another, from Oswego County, is made of grey slate and has a straight back. It is six inches wide by two and one eighth deep.

A very light drab slate knife was found a little east of Onondaga Lake, and is five and three eighths by one and one fourth inches. The back is quite irregular. Another, from the Seneca River, is six and one eighth by two and one half inches; and still another of red slate is five and one half by two inches. One from St. Lawrence County has a simple back, which is more convex than usual. It is seven and one half by two inches. A large and handsome one, of purple slate, is from Cayuga Lake, and is six and one fourth by two and one half inches.

Dr. Rau figured a very fine one, in his *Prehistoric Fishing*, from Newark Valley, in Tioga County, which is six and three fourths inches wide, and has a thick curving back. Two others in that work are from Pennsylvania and Massachusetts, and others are added from the Eskimo of Norton Sound in Alaska, one of which is a frequent New York form.

Although most of those mentioned have been found in a few localities, they probably have a much larger distribution, while it is also true that they become rarer as we proceed west and south. In but few instances is the sweep of the blade quite a half circle, and those with thick backs are less symmetrical than those without. Their purpose is evident, from their use by the present Eskimo, being identical with the Ulu or woman's knife. Whether that people actually reached New York will not be debated now, but the opinion of those who think the Northmen found them in New England nine

centuries ago, is certainly strengthened by these relics. At that time the interior of New York had no settled inhabitants, and the New England seaboard does not seem to have been reached by the Algonquins.

BANNER STONES

Dr. Abbott classed certain perforated 'relics as banner stones or ornamental stones, either used in the decoration of weapons or for suspension from the body, after the manner of breastplates.' He adds, 'Whatever may have been the manner of exhibiting such stone ornaments it is impossible to determine, but the fortunate possessor of such a specimen might well be proud of it. May it not be that such stones were the charms of the medicine men? Stones that were concealed from the general gaze of the crowd, and only brought to view with elaborate coverings on great occasions. They do not seem sufficiently abundant to be simply the ornaments of chiefs and warriors'.

All archæologists nearly have conceded that they were not intended for mere use, and an effort has been made to call them ceremonial objects. The good sense of the public is likely to prevail in retaining Dr. Abbott's name. They are peculiar to America, and are of early date although surface finds. They were unknown to the Iroquois, nor has their use been perpetuated by the later Indians; but they are much more abundant than Dr. Abbott supposed.

Mr. Fowke's treatment of banner stones is somewhat confused, but he sensibly retains Dr. Abbott's name, so much more definite than that of ceremonial objects. That they were suspended as ornaments for the body, however, seems in no way probable, while the central perforation gives force to the idea that they were placed on slender poles for badges of authority or use in ceremonies. At the same time they so commonly accompanied the owner on long journeys, that they may have had some superstitious use. They occur mostly east of the Mississippi or in its drainage.

They were not all drilled alike. Some New York specimens, unfinished, show a pointed spiral hole, such as might have been made by a flint drill. Others have a central core remaining, showing

that the drill was hollow. Dr. Rau thought that such an implement might have been made from the southern cane, now used for fishing-rods and pipe-stems, which varies greatly in size, and is hard enough for such a purpose. In any case, sand and water were employed, but the work was slow. The stone was picked into shape, a little polishing done, and this was followed by the drilling and general grinding and polishing.

Of the varieties usually described nearly all occur in New York, though sometimes in a fragmentary condition, and this is true of Canada also. They vary much in form, size and material, but are usually of some ornamental stone, quite frequently the striped slate. Out of 209 banner stones in Mr. Douglass' collection but five are from New York, where they are of frequent occurrence, but rarely on village sites. They are sometimes pick-shaped, like a broad double axe, heart and butterfly shaped, like reels, and sometimes make a double crescent with four points.

Fig. 184 is of light green slate, slightly banded, and is of an expanded double hatchet form, which might be called that of a butterfly. It was found not far from Three River Point. As in most of the others, the orifice is a little larger at one end than the other, and the average in this one is five eighths of an inch. The extreme width is four and three eighths inches, and it is two and three fourths deep.

Fig. 185 is a straight, pointed, and elliptical article of green striped slate from the Oneida River. It is here represented in profile, which is the narrow way, an unusual feature, and thus the perforation is made through the narrower central diameter. It is four inches long, one and one eighth wide, and three fourths of an inch deep. The material is fine. Fig. 186 is very different, generally circular, but a little angular. It is of green striped slate, and one side has been broken. The depth is four and one half, and the original width five and three eighths inches. A deep rectangular indentation meets the orifice above and below, thus shortening it; and it has the usual central expansion of the thinner forms. It comes from Onondaga Lake.

Fig. 187 is nearly elliptical, but the wings terminate in points. It has one deep indentation, like the last. It is of thin striped slate, thickened in the middle as usual, and the dimensions are five and one half in width by two and five eighths inches deep. This was found four feet below the surface by the outlet of Chautauqua Lake, above Jamestown.

Fig. 188 is also of striped slate, with an orifice averaging five eighths of an inch. It came from Camillus, and is of the butterfly form, but differs from most specimens in not having the wings in a plane. It is rather thick, and is four and five eighths wide by one and seven eighths inches deep. Those as heavy as this of course might have served some useful purpose, but they are not sharpened and show no marks of use. The perforation is larger than would be required for mere suspension, and it seems reasonable that a handle or staff was inserted in this. The difference in the terminal diameters of the orifice is usually an eighth of an inch.

Fig. 189 approaches a long heart shape, indented at each end, and with the customary central ridge. It is of olive green slate, and much narrower for its depth than usual, though many have this general form. The larger diameter of the orifice is seven sixteenths of an inch, and the stone is two and three fourths wide by four and one eighth inches deep. This and the next are from Brewerton. Fig. 191 is quite curious from its unsymmetrical form and unusual perforation, the latter being elliptical. The material is a beautiful green striped slate, showing a fault in the stone, a not infrequent feature. This is quite sharp near the perforated end, and the outline each way is not unlike some forms of broad celts. The greatest diameter is two and five eighths inches, and that of the orifice eleven sixteenths of an inch. Of course the latter was not made in the usual way, although neatly finished. This beautiful and remarkable article was found not very long since.

Fig. 192 is unfinished, and those in this condition are hardly rare, but this has unusual interest from showing the mode of drilling, as well as preliminary work. It is of a hard greenish and crystalline stone, picked all over into a symmetrical form, and ground above and below. On the lower edge the work of perforation was begun

with a tubular drill, and this was interrupted when a depth of but an eighth of an inch had been reached, leaving a core in the center. The implement is thick and heavy, somewhat hatchet-shaped, the blades being about equal on either side, and it is six and three eighths wide by two inches deep. This is from the Seneca River, and not from a village site, in which it agrees with some other specimens.

Fig. 193 is one of the frequent reel shaped articles, and is nearly perfect. The material is olive brown striped slate, three and five eighths wide by two inches deep. The orifice is half an inch wide. This form expands gradually to the center, and the terminal indentations are beveled to a moderately sharp edge. Quite often the upper and lower edges are grooved throughout, but this one has a plain surface. It comes from Lysander.

Fig. 200 is one of the most beautiful of these articles, and comes from Fabius or Pompey, much resembling one in the State Museum from that vicinity. It is made of a beautiful olive green striped slate, and in form is like a slender pickaxe, having a central ridge along both sides, from end to end. Each end has a slight projection. In the center, on one side, is a partially effaced ornament. It is seven inches wide by one and one fourth deep, and the orifice is nine sixteenths of an inch in diameter. No finer example of this form is on record.

Fig. 201 is a pick-shaped article of black slate, unique in some respects. The center is enlarged by a distinct concave sweep on either side, terminating in a central flattened surface. Near this is a lateral perforation on either hand, drilled precisely as in the gorgets. No other has been reported with holes like these, and if the stone had been placed on a staff, they might have served to attach pendent ornaments. The sides are covered with transverse lines, suggesting tallies. The blades are thin, and the total length is six inches, with a depth of one and one fourth inches. It was found on a camp site on the Seneca River in 1875. The ends are abrupt, and may be either broken or unfinished.

Fig. 202 is a thick, crescent formed banner stone from Skaneateles Lake, made of green striped slate, and one inch deep by three and three

eighths wide. The ends are rounded, and the orifice is a little over half an inch in diameter, contracting slightly in the interior of the stone. There are no village sites near, and but few small camps. Fig. 203 is elliptical every way, but roundly pointed at each end. It comes from Dresden, on Seneca Lake, and there is a fault in the green striped slate of which it is made. It is three and three eighths wide, and one and one half inches deep.

Fig. 204 is a straight pick form, *a* being the profile, and *b* the basal view. The base is longitudinally grooved, and the gradual expansion makes a central ridge unnecessary. It is of light olive green slate, having a depth of three quarters of an inch, and a width of three inches. The orifice is three quarers of an inch. This is from Oneida Lake.

Fig. 205 is another unusual form of light green striped slate, with an elliptical perforation, as in Fig. 191, but not so narrow. Both ends are grooved, and the lateral edges are almost sharp. It is two and one half inches wide and one and one half deep. The thickness is three quarters of an inch. A banner stone of bluish drab slate, from the Seneca River, is a little broken, and approaches the heart shape. The perforation is half an inch in diameter, but enlarges within, an unusual feature. This article is three and three fourths inches deep and three and one half wide. Another, of similar shape and found some miles from the same river, is two and one half inches deep and two and one eighth wide. This is made of an olive and mottled slate, the perforation in which averages over half an inch wide. Another of olive slate found near the last, has straighter and nearly parallel sides. There is the usual expansion in the center, and it is nearly three inches deep by two and one quarter wide. The perforation is about half an inch. Still another approaching the heart shape is from the head of Oneida Lake, on the north side. It is of bluish olive slate, three and one quarter deep and two and three quarters inches wide, and thickened in the center. There are lines across the edges. The orifice is over half an inch, and drilling coarse. Another of similar form comes from the west end of the same lake, and is of a dark mottled slate, three inches deep and three and one fourth wide. As a rule the perforation

varies but little from half an inch. Another, of a double hatchet form, is from the east end of the same lake, and is made of a porous bluish white stone, slightly banded. There are notches on one edge, and the orifice is finely drilled, being smallest midway.

A handsome fragment is from Onondaga Lake, where it was found in 1877. The material is bluish striped slate, very smooth and thin. The broken edge, which was along the perforation or nearly so, has been smoothed, and a small hole drilled in the upper corner, placed there for its later suspension. It might be called the butterfly pattern, and the original size was six inches in width and three and one half in depth. The thin wings continue very uniform in diameter till the central ridge is reached. Another, of similar form, but thicker, and made of purple and green slate, is from the same lake, and is finely drilled. It was originally five inches wide and two and one quarter deep.

One of these, made of polished greenstone, is from the Seneca River, and is two and one eighth long by one and five eighths inches wide. The orifice, however, is so small as to make it doubtful whether it may not originally have been the stem of a large platform pipe, recut for an ornament after being broken. It seems best adapted for such a purpose. Many of the heart shaped forms might be described.

An unfinished one, much like Fig. 192, is from the Seneca River, and a little broken; it is of greenstone and angular and thick, being about six and one half inches long and one and three eighths deep. A similar one, unfinished and picked all over, is from the same river, together with the next two. It is large and thick. One of the others is nicely picked and ready for grinding, except in being unperforated. It is of greenish grey sandstone, and the oblique wings are brought nearly to an edge. It is conspicuously thickened in the center, and the wings are at an angle suggesting those of a windmill. It was found in 1883, and is six and three fourths by two and one half inches. The other is of the same general form, but deeply indented above and below, and is of light brown sandstone, picked and partly ground. It is eight and one fourth inches wide. All these unfinished banner stones have a

general resemblance and were found within a distance of a few miles. In the last drilling was commenced with a sharp point.

A finished half circular banner stone from Cazenovia, of olive slate, has one wing broader than the other, and is three and three fourths inches broad by two and one fourth deep. Another half circular one of dark grey slate, thick and unpolished, is from the Seneca River, and is four and one half inches wide by two deep. A reel-shaped one, from the same river, is grooved above and below, and one side is deeper than the other. It is of dark green striped slate, three and one fourth wide by one and three fourths inches deep. The orifice is of the usual size.

Perfect banner stones of pick and crescent forms have been found near Cayuga, Canandaigua and Seneca lakes, and in Jefferson County. They are rare along the Mohawk, though sometimes found there. A large unfinished one is from Seneca Lake, and is seven and three fourths wide. A still larger unfinished one is from Baldwinsville, and is nine and three fourths inches wide, with quite oblique wings.

One only of the double crescent form, with four horns, has been reported, and that is broken. It is of green striped slate, and was originally six by five and one fourth inches. It is from Oswego County. This rare and beautiful form is also found in Canada and Ohio. A pick or hatchet form, quite angular, comes from Sullivan County, and is of variegated soapstone, thin and polished. It is five and three eighths inches wide.

Several banner stones are from the vicinity of Owego, in Tioga County, and a fine unfinished one has lately been described, recently found in Ellington, Chautauqua County. It shows a core where drilling was commenced, but is nearly half circular in form, instead of that of those already described. A curious article, suggestive of banner stones, is from Brewerton, where several have been found, made of brown sandstone. They are nearly circular, flat and notched, and with a rough ridge left in the center, from one indentation to the other. The diameter is four inches, and they are unique. The abundance of banner stones may be inferred from the selected examples given.

GORGETS

Gorgets are found in Europe, but they are different from those in America, where there has been much speculation as to their use. There is no direct evidence that they were twine twisters, as Schoolcraft thought. The Iroquois required no artificial means in making thread, and knew nothing of these implements. Perhaps as little can be said of their use as guards against the recoil of the bow string, for which some of them certainly would have been a clumsy contrivance. Dr. Abbott's conclusion is very much better, in supposing they were ornaments variously used. They are usually symmetrical, and drilled from both sides, each perforation terminating in a smaller hole in the middle. Occasionally they are left unfinished, and often seem merely ornaments. In that case it is probable they were not so much suspended as fastened to the wearer's dress by one or more holes, like some shell gorgets; or the superfluous holes might have been for the attachment of other light ornaments to them. However this was, they certainly had no rough usage, but may well have been worn like the frontal crown and the breastplate of the Hebrew high priest.

If they were ornaments, many may have had a more practical use. A few have a chisel or a gouge-like edge. They are of very wide distribution, and perhaps are as abundant in New York as anywhere, presenting many beautiful, and sometimes rare forms. This is not generally known, because of lack of publication. Mr. Douglass has 360 in his collection, and but 20 of these are from New York, their supposed abundance or rarity depending on the collector's field or tastes. They extend across the continent.

Dr. Abbott observes that they are found near the breast in New Jersey graves, and this holds good in New York, where, however, but few occur in tombs. He found most New Jersey specimens of one form. In New York there seem no bounds to the varieties. One was taken from a grave at Deming's Point in Dutchess County, which was of dark striped slate. It had one hole and 41 tally marks. The dimensions were four and one half by two and one fourth inches. Another, with but one hole, was taken from a burial mound

at Onondaga Lake, and others are from the extreme end of Long Island.

It will be found that those of stone did not essentially differ from the shell gorgets, worn by the Iroquois in colonial days, which usually have ornamental designs and two perforations for suspension. The well known buckle of the silver brooch, still in use, shows that the Indian had a good idea of the advantage of two points of contact. With good tools the flat ornaments of shell and stone usually had two longitudinal perforations, insuring the best modes of attachment or suspension. There seems abundant testimony, historical and otherwise, that the American stone gorget was an ornament, but it is not necessary to produce all this here.

Fig. 206 has two long parallel sides, and is made from a banded yellowish olive quartzite, which is almost a sandstone. It has three holes, and another has been commenced on one side. One end is gouge-like, and the dimensions are four and five eighths by one and one half inches. It is from the Seneca River. Fig. 207, from Monroe County is very different. The base line is one and three quarters inches long, and from this the sides rise three and one fourth inches with a concave sweep. The width is then two and three eighths inches, and above this the top lines converge to a point, making the extreme length four and one eighth inches. It is of brown striped slate, and has but one hole.

Fig. 208 is one of green ribbon stone, or striped slate, much like the last but with the tip broken. It has but one hole, and the extreme length now is four and one eighth inches. This is from the Oswego River. Fig. 209 is a beautiful gorget of green striped slate from Oneida Lake. It has two holes, tapering sides, and expanded and somewhat rounded ends projecting beyond these, rather abruptly leaving the sides. The length is three and five eighths and the breadth two and one eighth inches.

Fig. 211 is a remarkable gorget of dark olive slate, found in a small mound in Jefferson County, and which could have been used only as a breastplate. It has two small holes, and the sides are generally parallel. Two of them, however, expand near the base, which becomes nearly six and one half inches wide. The general

width is four and three fourths and the height six and three eighths inches. It is not thick. Another, found with it, differs slightly from it in size and form. The height is the same, but the base becomes seven and one fourth inches wide. This is of black slate. There is a ruder and smaller one in the Toronto collection, from West Ontario, which has but one hole. It is five and three eighths inches high by five and one eighth in extreme width. These are all that have been reported of this form. The figure here given is reduced.

Fig. 212 is a more frequent form with slightly convex edges, coming to a point at each end. In this article these points have been broken off, the original length being six and one half inches. The width is one and three eighths inches, and it has two holes. The material is bluish grey slate, and it comes from the Seneca River. Fig. 213 is a gorget found a few miles from the last, and is nearly triangular. The material is a banded red slate, and there is but one hole. It is five and three fourths inches long, two and three quarters at the broad end; the narrow end three quarters of an inch wide. Both these are reduced in the illustration.

Fig. 217 is a rare form, the upper and lower edges being curved and parallel, with the upper line longest. The ends are straight, but not parallel, and there are three holes near the center. It is of grey striped slate, and was found near the Oneida River. Fig. 218 has curving sides which do not reach a point at the ends. It is of brown slate, and the edges are moderately convex. It has two holes, and the length is five and one half with a width of two inches. It was found west of Onondaga Lake. Fig. 223 is of similar but broader form, and has two holes, perforated mainly from one side. The stone is striped with cream color and purple, and is of handsome material. It was found near Beaver Lake, Lysander, and is six inches long by one and three quarters wide. Fig. 224 is a curious gorget found in the western part of Onondaga County. The base and top are slightly convex, and the lateral edges are concave. Two of the angles are rounded. It has two holes, and is sharp. The length is four and one half and the extreme width two inches. The material is striped slate.

A very pretty elliptical gorget of dark green striped slate is from the Oneida River, and has two holes. It is two and seven eighths by one and one fourth inches. A very large and thin one from the same river, has two small holes. It is of green striped slate, and nearly rectangular. The dimensions are seven and one fourth by three and three fourths inches. One of polished sandstone, but with a sharp convex edge is from Black Creek, near Oneida Lake. The form approaches the triangular, and it is seven inches long by three and three eighths wide. There is but one hole. This seems more like an implement than most, but sharp edges are not uncommon.

Those with notches, also, are not rare. One of black slate, from Lake Champlain, has notched ends and but one hole. It is seven inches long by one and seven eighths wide. Others might be described from Chautauqua County, with this feature, as well as from other places. In fact they were so striking a part of personal decoration in early days, that they may be said to occur everywhere.

GROOVED AXES

Grooved axes are extremely rare in most parts of Vermont, New York and Canada, though not altogether unknown. Out of 419 in Mr. Douglass' collection but two were from New York, and Dr. Rau figured none. Mr. Gerard Fowke said, ' In the eastern and interior States the grooved axes are far more abundant than the celts of the same size, because, as a rule, only the larger implements of this class are grooved. All the ordinary varieties of axes and hatchets are found about Lake Champlain, by far the most abundant being celts or grooveless axes.' Between there and Lake Erie a grooved axe is a rare find indeed. In the later days they were not in use among the Iroquois as far as appears, and it may be questioned whether some occasionally found in New York, may not in some instances have been lost by collectors.

In his history of Onondaga, Mr. J. V. H. Clark represented that hundreds of these, particularly described, had been found on an Elbridge site, but farther inquiry proved this an unaccountable mistake. They sometimes occur, but are evidently foreign to the soil.

Fig. 215 is a narrow form, of light greenish stone with a groove all around. This is reduced in the figure and is from Jefferson County. Some occur of the more typical forms, specially in the southwestern part of the State. They are said to be more numerous east of the Mississippi than west, but this may be due to the number of collectors. The southern Indians have used them in historic times. The single grooves were for attaching the handles, and sometimes there are double grooves. They have been used by the Pueblo Indians.

While so rare in New York, Dr. Abbott reported many from New Jersey, and from every part. One axe weighed nearly 14 pounds, and several large caches of these implements have been found there. One contained 120 axes. Among three from Tioga County, N. Y., was one of eight pounds. There were none in the Wagman collection at Saratoga.

Celts and gouges are sometimes roughened or grooved for securing the handle, and a few broad axes rather suggest than have the groove. Fig. 219 is a flat axe of brown sandstone, not grooved across the surface, but with a deep and broad notch in each lateral edge. It is a rare form, altogether unlike the typical implement.

POLISHED PERFORATORS

Fig. 221 is a neat polished perforator of brown sandstone, from Madison County. It is two and three eighths inches long, and much like some bone perforators in general appearance. Those like this are rare, for the early comers used flint, and the Iroquois very much preferred horn and bone, yet these seem to have belonged to them.

Fig. 222 is from the same place, and is notched and more angular. The broadest part is near the point. This is two and three fourths inches long. Another of black basalt, with an oblique central notch, comes from the Nichols Pond site, the Oneida town of 1615. It is three and one eighth long by five eighths of an inch thick. This is decisive of its Iroquois use, but such a splinter of stone might be ground as easily as bone, the general form being the same.

GROOVED BOULDERS

In the Onondaga and Seneca territory specially, are found large boulders with straight grooves, from one to seven in number, and

very uniform in depth and width. Occasionally small stones are grooved in the same way. Fig. 241 is a reduction of one of these from the Minden earthwork, south of Fort Plain. It is a block of sandstone, 15 by 18 inches across, and has two grooves of the usual width and character.

Another of these, but much smaller, comes from Schoharie, and is five and three fourths by three and three fourths inches. This has three parallel and one cross groove, but they are reported much narrower than usual, being but little over a quarter of an inch wide. The block is of grey sandstone. Another small one comes from Frenchman's Island, in Oneida Lake. In this the groove is three quarters of an inch wide, with another partly within it. A few other small ones have been found, but usually large boulders were used. Of these larger ones Dr. Rau mentioned some in Massachusetts and New York.

One of clay slate and of irregular form comes from Dutchess County, and is 17 by 13 inches, and seven inches thick. It has one perfect groove, now 10 inches long, but originally more. This is half an inch wide and three eighths deep. Another groove is unfinished. One from Deming's Point is broken through the center of the second groove. This is now 10 inches long, but originally more. The width is five eighths and depth three eighths of an inch. Striæ appear in both.

The most remarkable of the large grooved boulders, is that described by Clark in his history of Onondaga, and it was the first to attract much attention. The Gothic letters XIIIII fairly represent the arrangement of the grooves. The boulder is of corniferous limestone, 23½ by 22 inches across. The grooves are wider than usual, being three quarters of an inch, and the striæ are obscure. The longest groove is about 15 inches. It was in the ravine by the old Indian Fort in Pompey, reputedly of recent occupation. Another from that vicinity is also of limestone, 26 by 22 inches across. There are seven grooves irregularly dispersed, five eighths wide and three eighths of an inch deep. The grooves are about seven to 12 inches in length. A small block of blue limestone, much weathered, has two grooves. Another in the same condition, has

five grooves, and the block is 16 by 18 inches. One of these grooves intersects the rest. They are five eighths wide, and three eighths of an inch deep. One of red sandstone, 15 by 18 inches, has one groove, 14 inches long, and of the usual width and depth. Some of these Pompey stones came from historic sites, and were undoubtedly used within the last three centuries.

A fine one of sandstone, from Yates County, has three grooves about 20 inches long and of the usual width and depth. Another has five grooves, and still others have been found there. Two were found in Hector, Tompkins County. One is of slate, 10 by 10, and about three and one half inches thick. It has five grooves across the face, which are nearly parallel. Four of these are but little over half an inch apart, and are half an inch wide and a quarter deep. The fifth is a little wider. The other stone is also of slate, eight and one half by 12 inches, and three and one fourth thick. It has two grooves, and all these are striated like the rest.

Two more in Pompey are on either side of a stream, and partly imbedded in the banks. The exposed part of one is 24 by 30 inches, and the ends of the five grooves are buried in the earth. They are nine, 16, 14, 11, and eight and one half inches long. The boulder is common limestone. The other is in the west bank of the stream, and is of corniferous limestone, partly exposed. Both boulders extend into the brook. The exposed part of this is 24 by 30 inches, and has two grooves, which are nine and 10 inches long. The grooves and striæ are carried through the flint nodules as in the others, a feature best seen when the stone is wet.

The use of these stones is of interest, and nothing has been suggested but that of straightening and smoothing arrow shafts, by rubbing them in these grooves. There are objections to this, but they may not be insuperable. In the case last mentioned, the pointing of the grooves against a steep bank would embarrass arrow making, the most convenient position being parallel with the stream. If the shaft were long the difficulties would be increased. That water and sand were used may be inferred from the parallel striæ, and the usual position near a stream. That the grooves were made with a purpose directly connected with their size, may be inferred

from the uniformity of that size, and the absence of narrower and shallower grooves. As to the period, they may have been in use in Onondaga County and vicinity for a hundred years after the forming of the Iroquois League, but probably less.

The Indians of the present day have simple methods of arrow making, and whether their fathers made these grooves with so much labor, for this purpose, may be a question still. The strong point is that there is no other apparent use for them.

Grooves of another kind are not rare, and among these are the sharper cuts made by sharpening tools on boulders. A large stone was often very convenient for this purpose, and some may still be seen on old village sites. As the Indians learned to melt and cast metals, they sometimes made use of a small stone for a matrix, and such stones are occasionally found. So are whetstones, easily recognizable by their marks of use. They are commonly slender and small.

After the foregoing was written, Mr. A. G. Richmond described a large grooved boulder, weighing 1970 pounds. Of this he says, 'There are three grooves at one end, pretty well off on the slope. Three more toward the center, and a seventh one started in the center.' He thinks they were certainly used in working arrow shafts, and while there are certain difficulties in the position of those found in place, he makes suggestions worthy of consideration. These are quoted here, ' My theory is, and it would answer on every stone I have seen, that they sat astride, and worked the arrow in front of them, as my observation is that they all have grooves across, rather than lengthwise of the stone. Another thing makes me think they were made for this purpose, and that is that when the groove reaches a width sufficient for the maximum size of arrow shafts, they proceed to make a second groove. If it was for some purpose that did not require a uniform or absolute size, one groove would answer every purpose.'

The crosswise grooving, however, while general is not invariable. The uniformity of the grooves, of which he speaks, is one of the remarkable features of these curious stones.

MISCELLANEOUS

Fig. 220 is an elliptical brown sandstone pebble, two and one sixteenth inches long by seven eighths of an inch wide, and having a central groove and notched ends. It may have been a sinker. Fig. 236 is a perforated ball from Elbridge, found near an earthwork. It is a soft brown sandstone, one and seven eighths wide by one and three eighths inches deep. The top and the bottom are unequally flattened, and the diameter of the opening is less than an inch. A curved yellow stone, much like a horn in outline, is perforated at the broad base. It comes from the Oswego River.

Many years ago a fine carving made from the black slate of the northwest coast, and in that style, was found in Tioga County, but whether it was brought by an Indian or lost by a white man, may be a question. It is a characteristic piece, and of its ultimate origin there can be no doubt. A Sandwich Island adze was found in Marcellus some years since, but the cause for this seems clearer. It was brought there by a recent traveler, was lost and found again. Similar instances might be cited of unexpected articles found even in Indian hearths and graves.

Mr. Fowke considered stone cones rare in the South and West, and they are still rarer in New York. A true stone cone, however, comes from Jefferson County, and is two inches high. They have been reported nowhere else, but small pyramids occur. A pebble, flattened like a muller, has a groove lengthwise from the flat surface at each end. It is four inches long, and comes from Cayuga County, where other odd forms are found. An oval pebble, with perforations representing eyes, has its edges chipped. This is from Brewerton, but similar things occur elsewhere, being usually recent forms. Many puzzling pieces are probably unfinished, and of the intention of others we know very little. Some doubtful forms have been passed over, there being no present occasion to discuss their authenticity, while others of undoubted value have been regretfully left unnoticed.

Plates, blocks and ornaments of mica have been found in Cayuga, Cattaraugus, Chautauqua, Chenango, Monroe, Oswego, Suffolk, and perhaps other counties. They are quite rare.

While the Iroquois made many records by pictures, these were usually on wood or bark, but sometimes were painted on stone. Such examples were known in St. Lawrence and Montgomery counties. No engraved pictures in rocks have been reported here, but a few occur in large stones, notably on the Hudson. There is an account of footmarks in stone in Suffolk and Westchester counties, and in the latter mortars are common, excavated in the rocks.

Stone heaps occur sparingly all over New York, and there are frequent allusions to the aboriginal custom of casting stones on such heaps, in early records. The stone heap near Schoharie creek was the most noted of such monuments, and was constantly added to as late as 1753, if not later. Such heaps sometimes covered graves, but not invariably. The Schoharie tumulus was reported as four rods long, between one and two wide, and from ten to fifteen feet high, being of the largest size. An early account of it will be found in the *New York Documentary History*. Small heaps of stone are sometimes found within the lines of forts, gathered as defensive missiles, but they are not conspicuous.

This bulletin completes a general view of the stone implements and ornaments of the aborigines of New York, to which the paper on articles of chipped stone formed the introduction. Abundant materials are in hand for others on the interesting earthenware of our early inhabitants, as well as their articles of bone, horn, shell, wood and metal, of scarcely less interest and beauty, should it be determined to complete such a series. Any information on either rare or common articles of this kind will be gratefully received. Figures are desirable, with full descriptions available for record, but specially notes of locality. This most important point in comparative study should never be neglected. Of course contributions to the State Museum are very desirable, and many collectors may be disposed to do a public service in this way, but clear and full notes, to be compiled and preserved, will be an acquisition of no

small value. Maps of localities, with descriptions of sites and finds, will be no less prized, specially from places where little has yet been done. These preliminary bulletins will reach many, it is hoped, who will take an active interest in the matter. There are many good private collections of aboriginal articles, and a simple systematic description of the New York relics in these would be a great aid in scientific research. It is a work in which many might and should share, and the prospective results are great indeed.

EXPLANATION OF PLATES

Many figures are greatly reduced for lack of space, and for convenience in arrangement some small ornaments are not placed in consecutive order. For full descriptions given in bulletin, see index under *Plates*.

FIG.	NAME	MATERIAL	LENGTH IN INCHES	WIDTH IN INCHES	DEPTH OR HIGHT
1	Celt	Greenstone	5⅜	2	
2	"	Brown sandstone.......	4⅝	2⅛	
3	Plummet	Slate	2	....	
4	Celt	Green striped slate.......	3¾	3⅛	
5	Ornament [a]	Red pipestone	1½	+¾ wide base —¼ nar'w end	
6	Chisel.........	Brown sandstone.......	5⅞	1⅛	
7	Celt	Grey "	3⅛	9/16	
8	"	Brown "	4	¾	
9	"	Green striped slate.....	4⅛	....	¾ deep
10	"	Brownish drab sandstone	8	2⅛	
11	Chisel	Black basalt	2⅛	¼	
12	Celt	Greenstone	2¼	⅜	
13	"	Black basalt	3	1	
14	"	" "	3⅞	1⅞	
15	"	Light olive green slate..	2¾	1½	
16	"	Dark green striped " ..	4½	2½	
17	"	Quartzite	2¼	1½	
18	"	Brown sandstone.......	1¾	½	
18 a	"	Black basalt...........	1¾	¾	
19	"	Grey sandstone	5½	2¼	
20	"	Green striped slate.....	2¼	1½	
21	"	Light olive green "	5⅛	2⅜	
22	"	Brown sandstone.......	4⅛	1	
23	"	Striped slate...........	6⅞	⅞	⅝ deep
24	"	Brown sandstone.......	3⅜	1	
25	"	" "	2⅜	⅝	
26	"	Dark slate.............	11½	1¼	
27	"	Dark steel grey sandstone	9	15/16	
28	Pick or hoe....	Polished sandstone.....	9¼	....	1¾ thick
29	Celt	Green slate............	3½	1⅛	
30	Adze..........	Brown sandstone.......	9⅞	1⅜	
31	Celt	Grey granite..........	1⅝	1⅛	
32	"	Dark green marble.....	2⅛	2	
33	"	Black basalt..........	1½	13/16	
34	"	" "	5⅜	2	
35	"	Basalt	1¾	1⅝	
36	Gouge	Bluish striped slate.....	7⅜	2⅛	
37	"	Brown hæmatite	3¾	2¼	
38	"	" sandstone..	3⅜	1½	

[a] For special names of ornaments, see description in bulletin.

EXPLANATION OF PLATES, *continued*

FIG.	NAME	MATERIAL	LENGTH IN INCHES	WIDTH IN INCHES	DEPTH OR HIGHT
39	Gouge	Black basalt............	2⅞	1¼	
40	"	Grey sandstone..........	4⅝	1¾	
41	Ornament......	Red pipestone..........	1+	....	
42	Gouge	Greenstone.	6¼	2½	
43	"	Mottled "	4¾	2	
44	Ornament......	Sandstone.............	1	1	⅜
45	Gouge	Black basalt	8¼	2¼	
46	Ornaments (3) .	Stone beads	½	½	
47	Stone ball......	Black slate	1	15/16	
48	Beads.........	Slate	15/16	13/16	
49	Stone ball......	Dark grey quartzite.....	......	2⅛ diam	
50	Ornament	Sandstone	⅞	....	
51	Stone ball......	Pink quartzite..........	......	2½ diam	
52	Ornaments	Clay concretions	various	....	
53	Stone ball......	Black slate	1	⅞ diam	
54	Gouge	Dark olive green slate ...	5	2	
55	"	Ironstone	4⅛	1⅞	
56	Ornament	Pipestone	3½	1¼	
57	"	Red slate..............	1	....	
58	"	"	......	1¼ diam	
59	"	Pipestone	.....	1+ "	
60	"	"	1⅝	1⅛	
61	Gouge	Mottled stone...	4⅛	2⅜	
62	Pebble.........	Brown sandstone	......	3⅜ diam	1½ thick
63	Pestle.........	Grey "	7	....	
64	Double muller..	Grey sandstone	3½	3½	2⅞ deep
65	Pestle.........	Sandstone	3⅜	1	
66	Adze..........	Black slate	4½	3¾	
67	Pestle.........	Brown sandstone	8¾	2¼	
68	" (carved)....	" "	15	2½	
69	" "	Sandstone	6¾	1¾	
70	"	a	9½	2¼	
71	"	Brown sandstone.......	8⅜	1¾	1⅛ thick
72	Celt and gouge	Grey "	2¾	1¾	
73	Pestle	Brown sandstone.......	5¼	2¼	
74	"	"	2½	1¾	
75	"	Grey sandstone.........	4⅛	2¼	
76	Muller	Sandstone (pebble).....	¾	¾ b	
77	Sect'n of a vessel	Potstone	......	20 across handles	10 high
78	P'ce of potstone	"	2	1½	1 deep
79	Notched pot-stone rim....	"	......	3¼	2¾
80	Sinker.........	"	2⅜	1⅛	
81	Handle	"	......	1½	1½ proj.
82	Ornament	Pipestone	......	1 diam	

a Not given. *b* Use unknown.

EXPLANATION OF PLATES, *continued*

FIG.	NAME	MATERIAL	LENGTH IN INCHES	WIDTH IN INCHES	DEPTH OR HIGHT
83	Handle	Potstone		3	2¼ proj.
84	Ornament	Light drab slate	1¾	¼	
85	Pestle	Brown sandstone	1⅜	¾	$\frac{11}{16}$
86	Sinew stone	"	3⅞	1⅝	
87	Ornament	Pipestone		$\frac{11}{16}$	
88	Beads	Slate	⅞		
89	Pestle	Brown sandstone	4⅝	1⅜	
90	Plummet	Dark "	4½		1⅛ thick
91	"	Grey "	4¼		1½ "
92	"	Red "	3⅝	1½	
93	"	Greenstone	3½	1½	
94	"	Red granite	2	1¾	
95	"	Hornblendic gneiss	2½	1⅛	
96	"	Greenstone	3	1⅜	
97	Pipe	Black soapstone			4½ high
98	"	Yellow sandstone			1⅞ "
99	"	Dark soapstone			1⅞ " 1¼ deep
100	"	Black marble	4¾		
101	"	White "			2⅜ high
102	" bowl	Dark soapstone			1⅞ "
103	Bird pipe	" green slate			7½ "
104	Pipe	Yellowish grey stone	2½	2¼	⅞ "
105	"	Soapstone		1¾ (?)	1½ "
106	"	Black marble	3⅜ fr. tip to "		
107	"	Grey quartzite			2¼ "
108	"	Dark soapstone			1½—"
109	"	Dark slate	5⅞		2¼ "
110	"	Grey stone	3½		2 "
111	"	Brown sandstone			2 " 1¾ thick
112	"	Sienna marble			2¼ high
113	"	Sandstone			2½ deep
114	"	Dark stone			3½ high
115	"	Crystalline "	3¾		
116	"	Sandstone			2¾ high 1¼ deep
117	Bird pipe	Green slate	3¾		
118	Pipe	Steatite	3¾	1 diam	
119	"	Grey limestone			2 high
120	"	Dark soapstone	2¾		
121	Muller	Greenstone		4	2 deep
122	Tube	Dark green striped slate	3½	1¼	
123	"	Grey striped slate	5⅝	1 diam	
124	"	Light olive green slate	3¼+		
125	"	Striped green slate	7		

EXPLANATION OF PLATES, *continued*

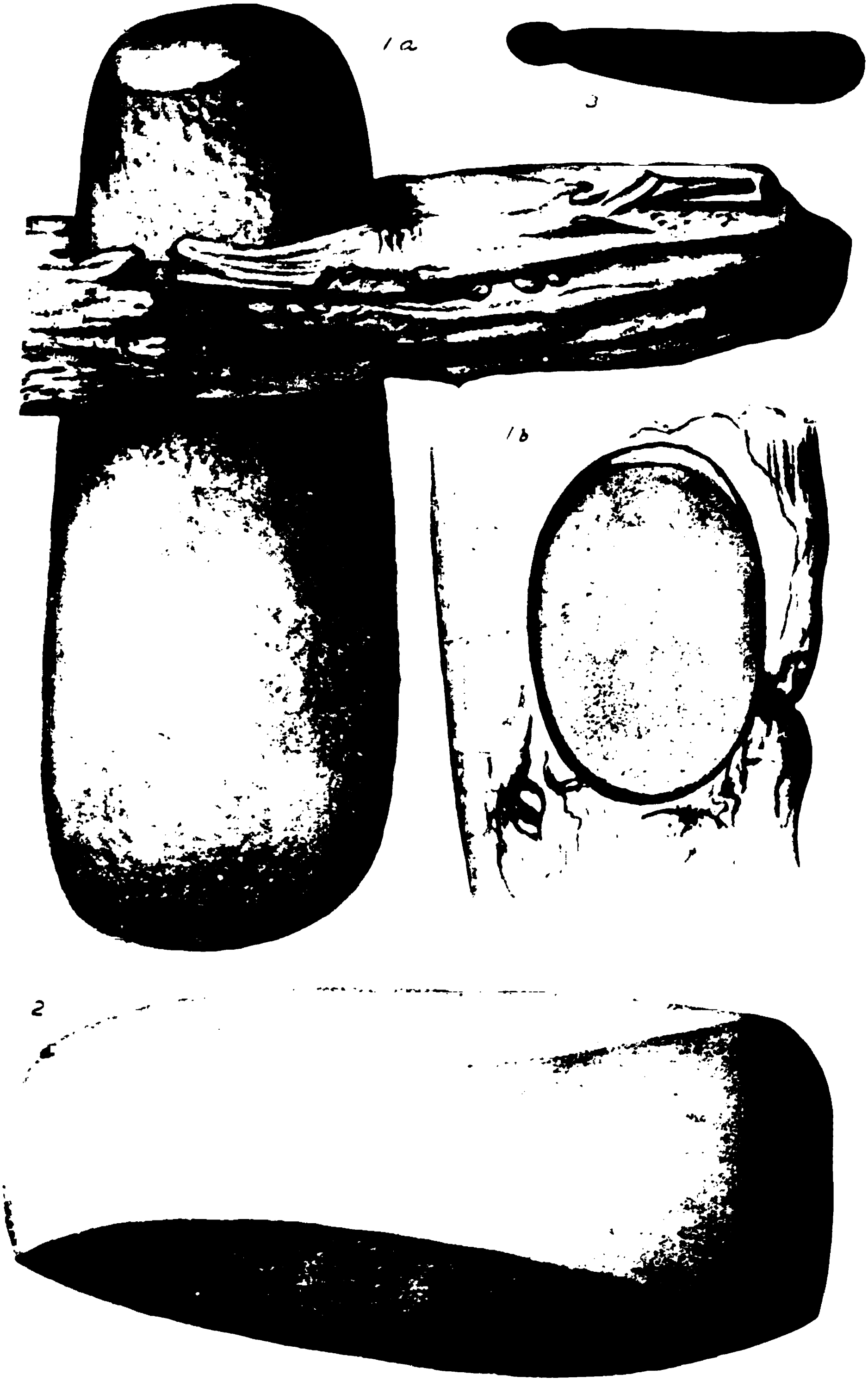
FIG.	NAME	MATERIAL	LENGTH IN INCHES	WIDTH IN INCHES	DEPTH OR HIGHT
126	Ornament	Greenish slate	......	11/16 long diam	
127	"	"	11/16+	....	
128	Tube	Sandstone (?)	9½	1⅛ diam	
129	"	Sandstone	4½	1¼ diam	
130	"	Soapstone	8½	....	
131	Bayonet slate ..	Bluish striped slate	8⅞	⅞	
132	" " ..	Striped slate	4⅞	....	
133	Plummet	Brown sandstone	2 5/16	1⅜	
134	"	Quartz	2½	1¼	
135	Amulet	Green striped slate	......	9⅞ fr. tip to tip	
136	"	" "	3½	....	1½ high
137	"	" "	6⅛	3 at tail	
138	"	Pipestone	2 3/16	....	
139	"	Green striped slate	3¼	....	
140	"	Trap rock	6⅞	....	1½ high
141	"	Mottled stone	3⅜	....	1¾ "
142	"	Green striped slate	4½	....	1 high at tail
143	"	" "	5	....	1¾ high
144	"	" "	3⅜	....	1⅜ "
145	"	Grey "	5⅝	....	
146	"	Mottled dark stone	4½	1¾	
147	"	Dark green striped slate ..	5⅞	¾	¾ high
148	Ornament	Pipestone	⅝	....	
149	"	"	1 9/16	13/16	
150	"	"	3/16	....	
151	Pipe	Dark green soapstone ..	3	....	1⅛ thick
152	"	Green sandstone	3¾	....	
153	"	Stone	3⅝	....	
154	Boat stone	Striped slate	4⅛	1+	⅞ high
155	"	Green striped slate	3¾	1⅛	¾ "
156	"	Brown slate	3⅞	....	1⅛ "
157	"	Green striped slate	5½	....	1⅜ "
158	"	" "	4¼	1½	1¼ "
159	Cup	D'k blue gr'n striped slate	......	2¾	
160	"	Soapstone	......	2⅝ long diam	
161	D'ble edg'd knife	Grey slate	2⅜	1¼	
162	Ornament	Brown sandstone	......	1 diam	
163	Cup	" "	......	1¼	
164	D'ble edg'd knife	Grey slate	2¼	1¼	
165	Sinker (?)	Light greenish slate	4¾	¾	
166	D'ble edg'd knife	Dark slate	5⅝	1¼	
167	"	Grey "	3¾	1⅜	
168	"	Dark "	1⅝	....	
169	"	" "	2½	1	
170	"	Red "	⅝	1⅛	

EXPLANATION OF PLATES, *continued*

FIG.	NAME	MATERIAL	LENGTH IN INCHES	WIDTH IN INCHES	DEPTH OR HIGHT
171	D'ble edg'd knife	Bluish slate............	2 3/8	1 1/4	
172	"	Dark "	3	1 3/8	
173	"	Grey "	1 1/4	1/2	
174	Omitted.......	....	......	....	
175	D'ble edg'd knife	Dark "	3 3/4	1 3/8	
176	"	Grey "	2 7/8	1 1/8	
177	Woman's knife..	Slaty sandstone.........	2 7/8	....	2 1/4 deep
178	" ..	Hard black slate........	3	....	1 1/8 "
179	" ..	Brown sandstone.	......	5 1/2	2 "
180	" ..	Grey sandstone.........	......	6 1/8	2 1/4 "
181	Ornament......	Pipestone	2 1/8	1 +	
182	"	"	1 5/16	3/8	
183	"	"	1	3/4	
184	Hammer stone..	Light green slate.......	......	4 3/8	2 3/4 deep
185	" ..	Green striped slate.. ...	4	1 1/8	3/4 "
186	" ..	" "	......	5 3/8	4 1/2 "
187	" ..	Striped slate	......	5 1/2	2 5/8 "
188	" ..	"	.....	4 5/8	1 7/8 "
189	" ..	Olive green slate	......	2 3/4	4 1/8 "
190	Ornament......	Pipestone	......	....	
191	Hammer stone..	Green striped slate......	. ....	2 5/8 diam	
192	" ..	Greenish crystalline stone	......	6 3/8	2 deep
193	" ..	Olive brown striped slate	......	3 5/8	2 "
194	Ornament.	Pipestone	1	1/2	
195	"	"	1 7/8	1	
196	"	Marble	......	7/8	1 1/8
197	"	"	......	1	1
198	"	Pipestone	3/4	....	
199	"	"	......	1 1/8	3/16
200	Hammer stone..	Olive green striped slate.	......	7	1 1/4 deep
201	" ..	Black slate	6	....	1 1/4 "
202	Banner stone...	Green striped slate......	......	3 3/8	1 deep (?)
203	Hammer stone.	" "	......	3 3/8	1 1/2 deep
204	" ..	Light olive green slate..	......	3	3/4 "
205	" ..	Striped slate...........	......	2 1/2	1 1/2 " 3/4 thick
206	Gorget.......	Yellowish olive quartzite	4 5/8	1 1/2	
207	"	Brown striped slate.....	4 1/8	2 3/8 1 3/4 at base	
208	"	Green ribbon stone.....	4 1/8	....	
209	"	" striped slate.....	3 5/8	2 1/8	
210	Ornament	Pipestone	2 3/8	3/8	
211	Gorget........	Dark olive slate	....	6 1/2 at base 4 3/4	6 3/8 high
212	"	Bluish grey "	6 1/2	1 3/8	

EXPLANATION OF PLATES, *continued*

FIG.	NAME	MATERIAL	LENGTH IN INCHES	WIDTH IN INCHES	DEPTH OR HIGHT
213	Gorget........	Red slate	5¾	2¾ oad end; ¾ nar'w end	
214	Boat stone....	Brown slate	5⅛	1¼	⅞ high
215	Grooved axe...	Light greenish slate.....	5¾	2½	
216	Plummet	Green basalt...........	1 13/16	....	1 thick
217	Gorget........	Grey striped slate.	......	4⅛	2⅛
218	"	Brown slate	5⅛	2	
219	Flat axe.......	" sandstone.......	4¼	2⅞	
220	Pebble........	" "	2 1/16	⅞	
221	Polished perf...	" "	2⅜	....	
222	" ...	Sandstone	2¾	....	
223	Gorget........	Striped (cr'm & pur.) stone	6	1¾	
224	"	Striped slate	4½	2	
225	Ornament......	Limestone	......	1½	
226	Mask..........	Pipestone	......	¾	1
227	"	"	......	9/16	⅝
228	"	"	......	¾	¾
229	Ornament.. ...	"	......	¾	
230	"	"	......	11/16	½
231	"	"	......	1 5/16	9/16
232	Mask..........	"	......	¼	⅝
233	"	"	......	7/16	½
234	Ornament......	"	3	1⅝	
235	"	"	2⅝	1⅝	
236	Ball (perforated)	Brown sandstone	......	1⅞	1⅜ deep
237	Ornament......	Pipestone	......	1	1 3/16
238	Mask..........	Grey marble	......	1⅜	1¾
239	Cob. st'ne (carv.)	Sandstone	......	2½	3
240	Ornament......	Pipestone	......	11/16	⅜
241	Grooved bould.	Sandstone	18 (?)	15	
242	Ornament	Slate	......	1⅛	1⅜
243	"	Pipestone	1⅛	7/16	
244	"	"	1½	3/16	
245	Ornament (serp)	Greenish slate..	3⅞	¾	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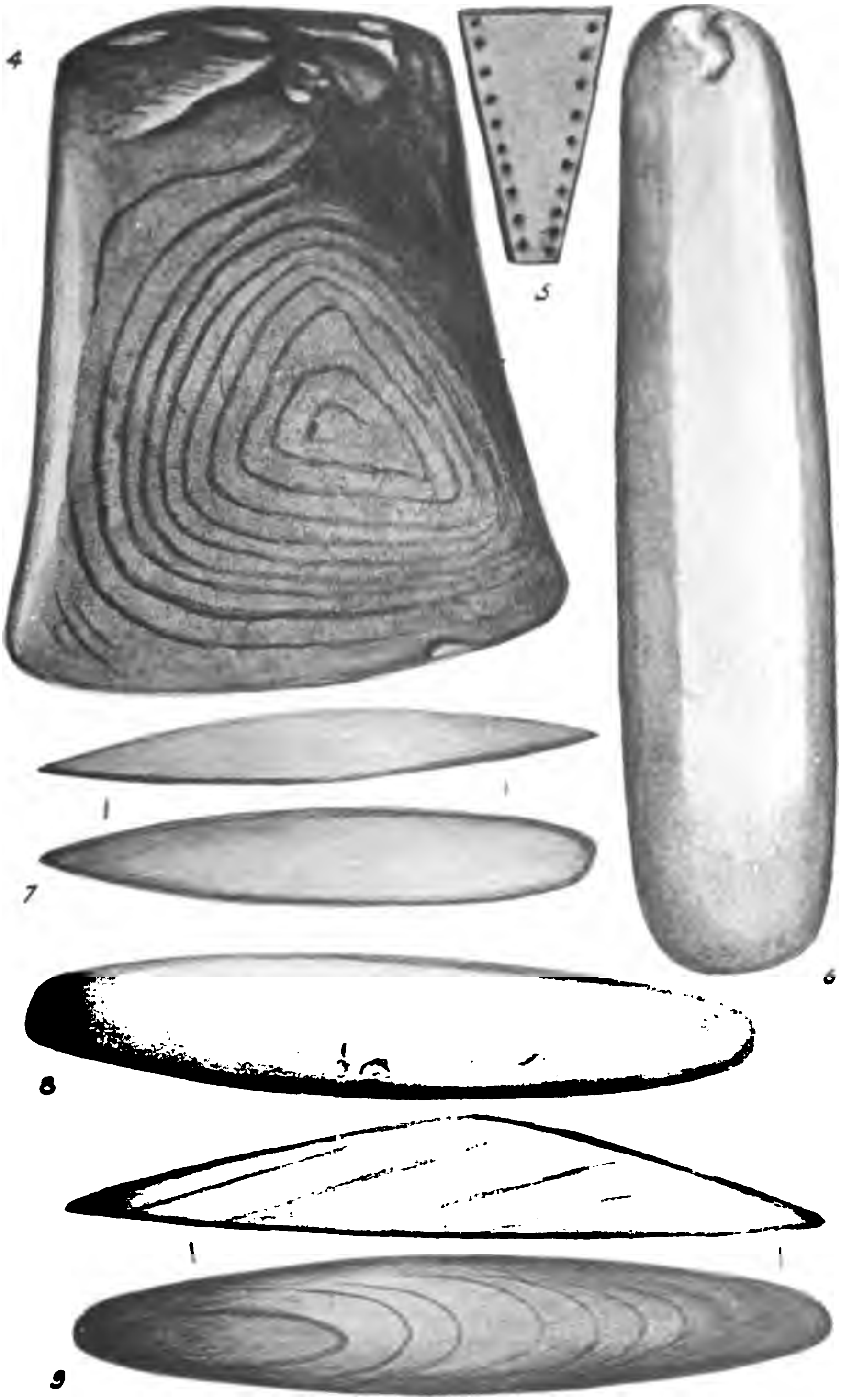
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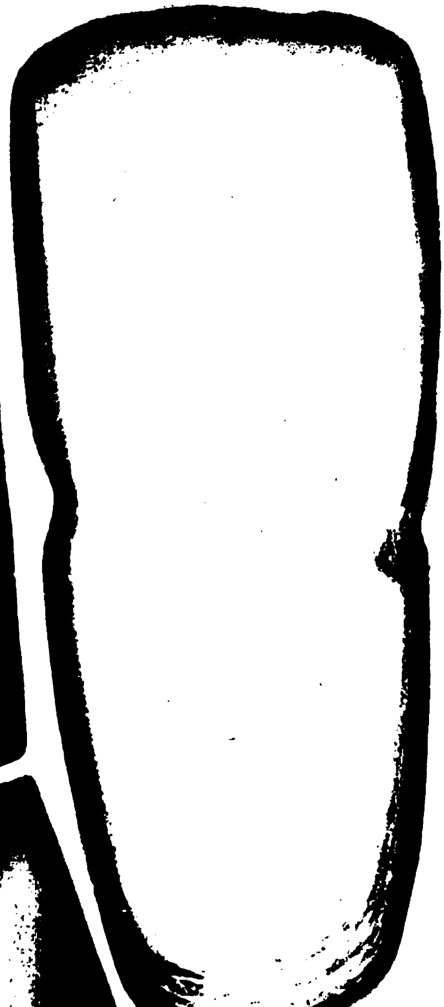

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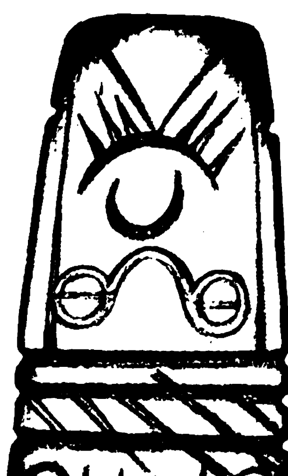

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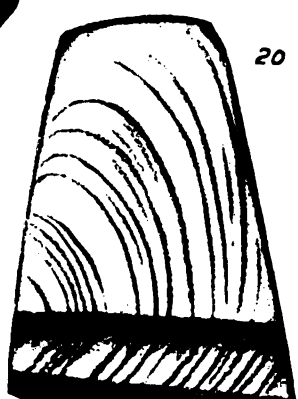

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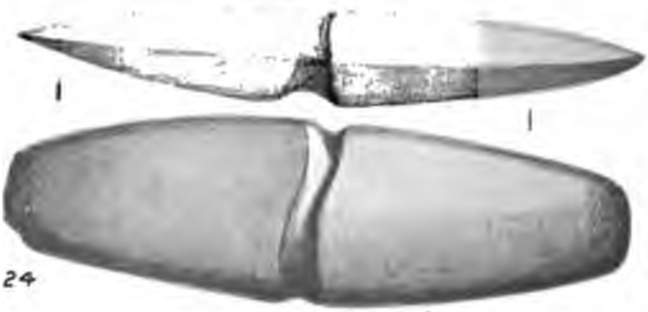

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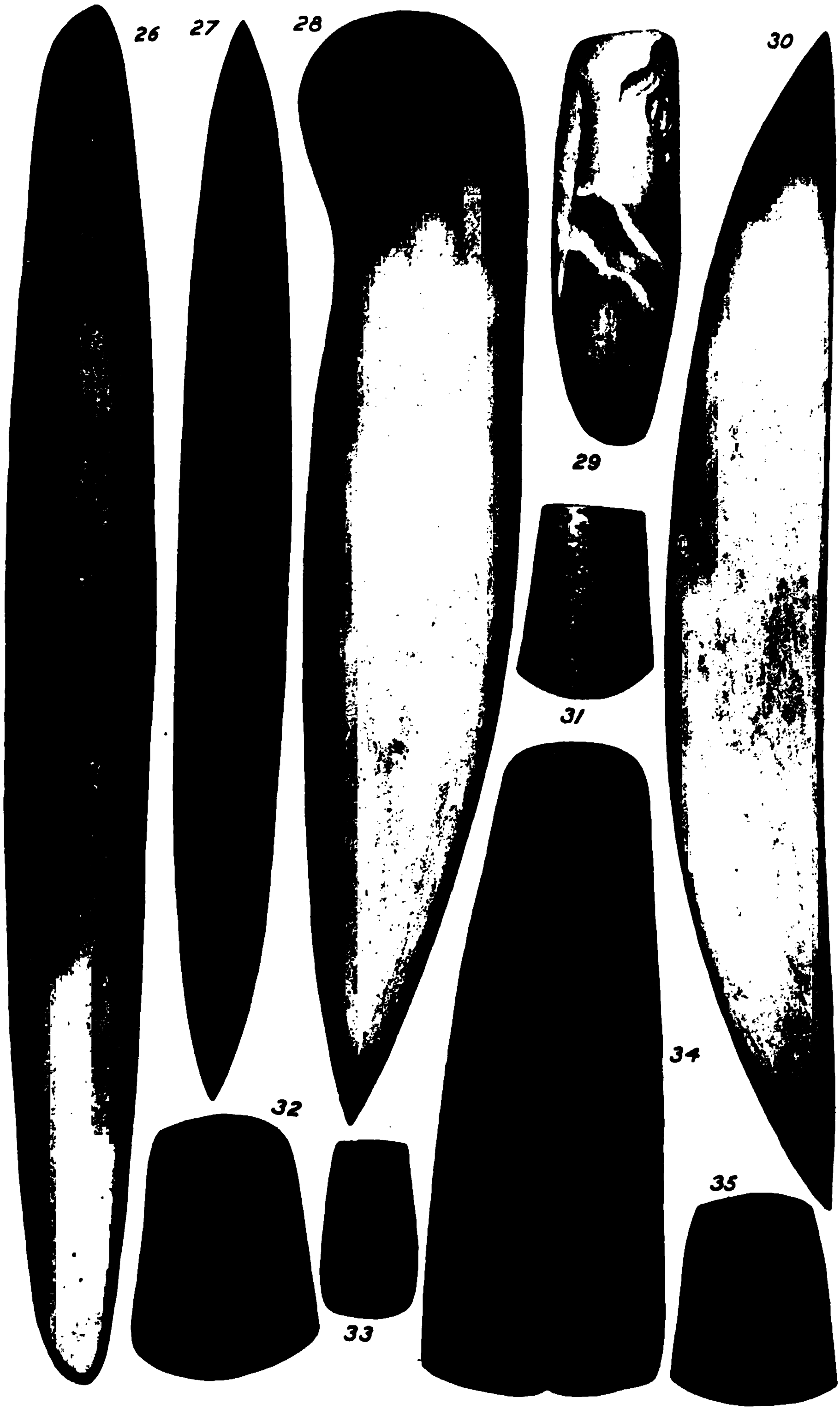
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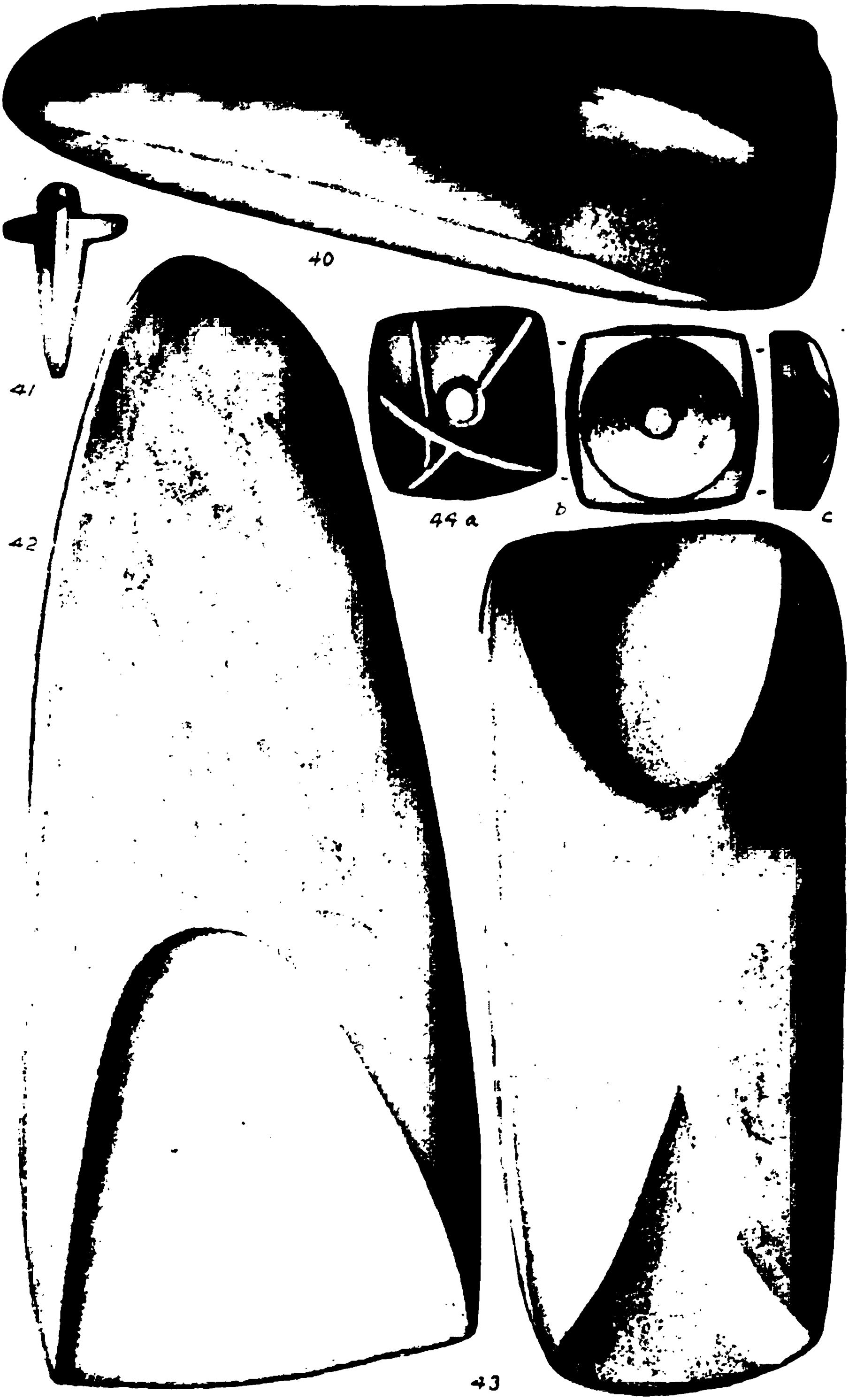
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b
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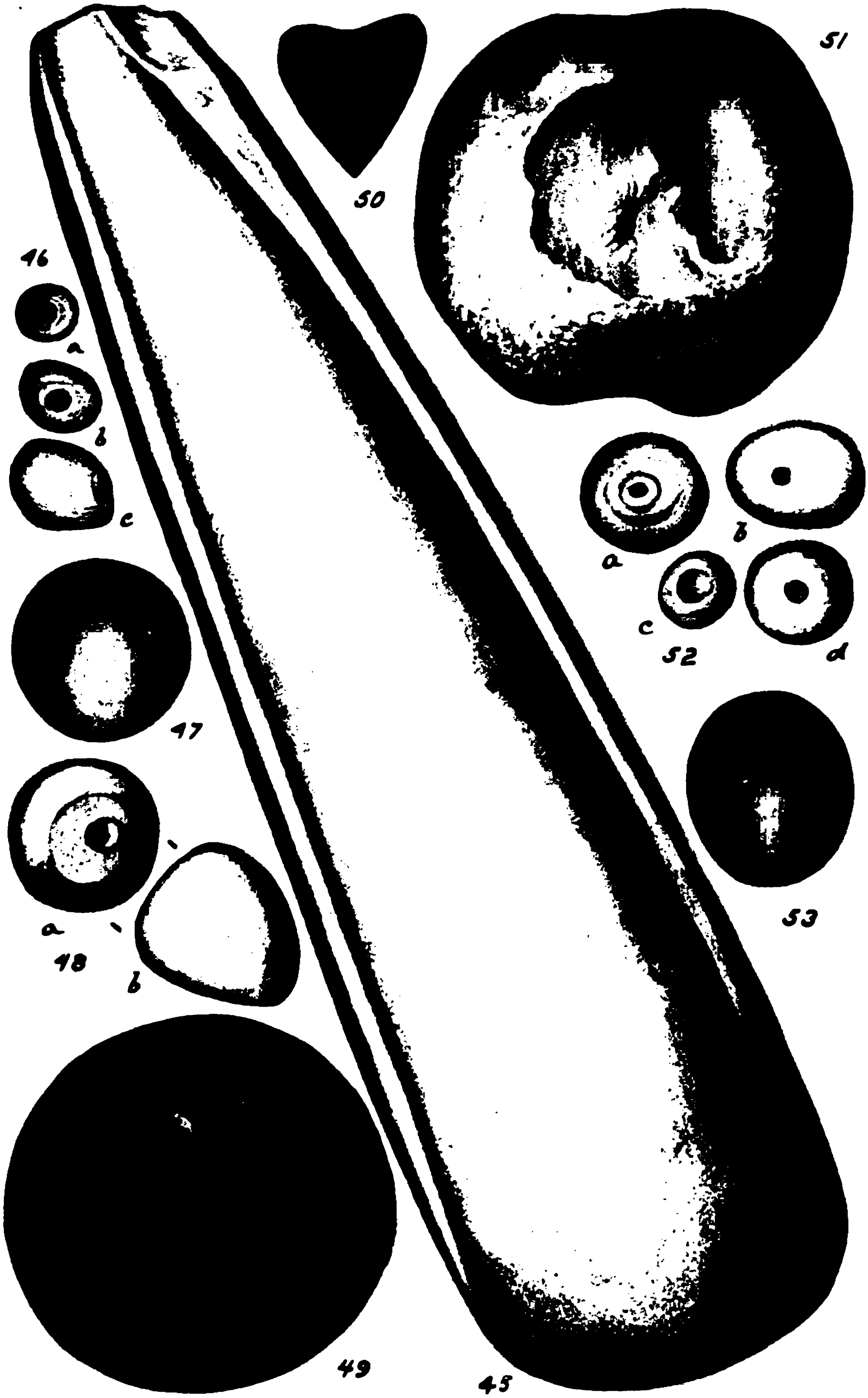
43


46
a
b
c
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b
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45
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b
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52
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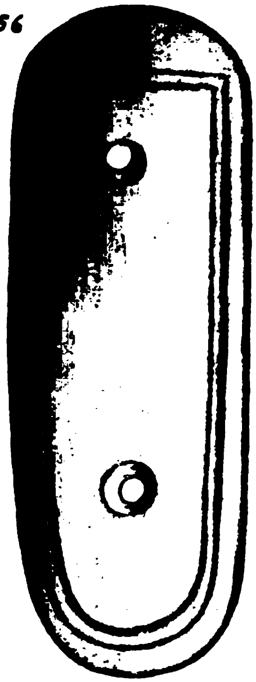
56



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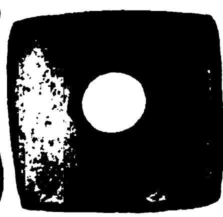

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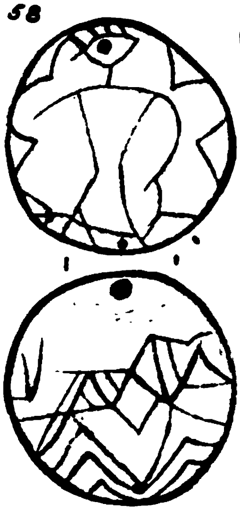

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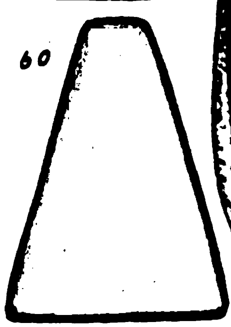

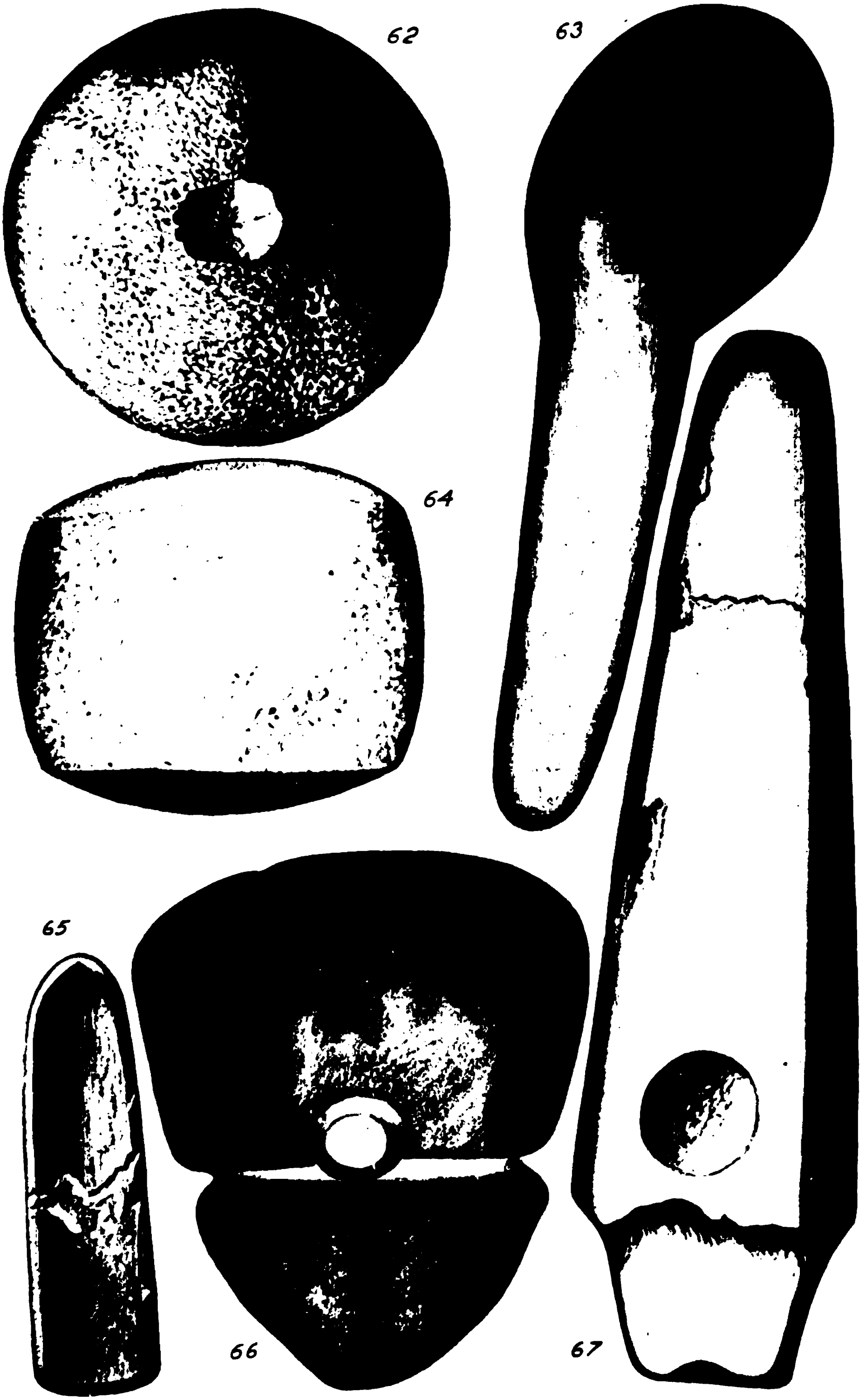
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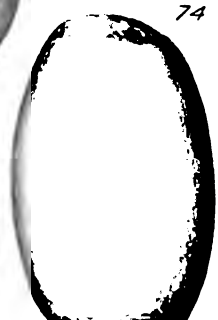

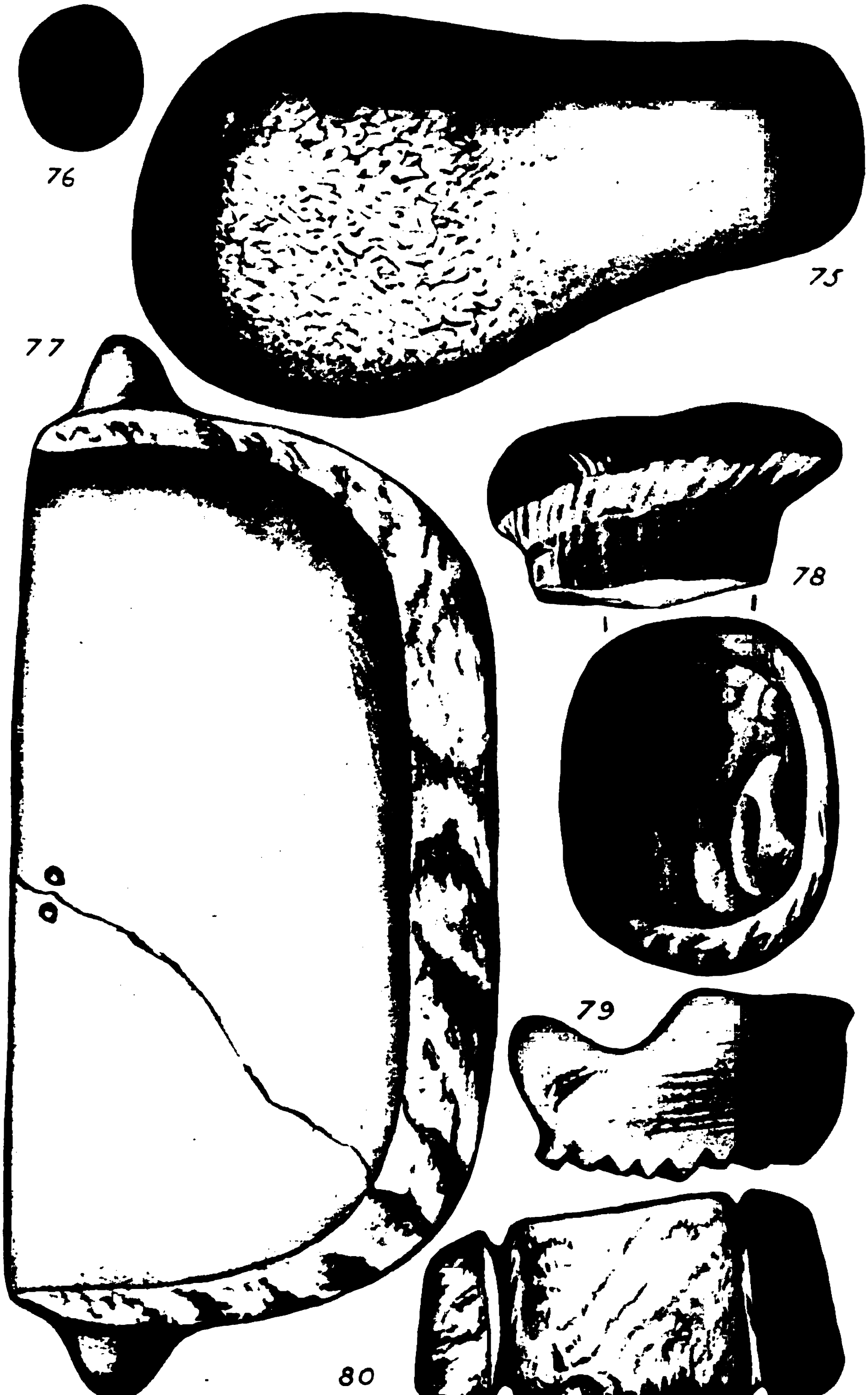
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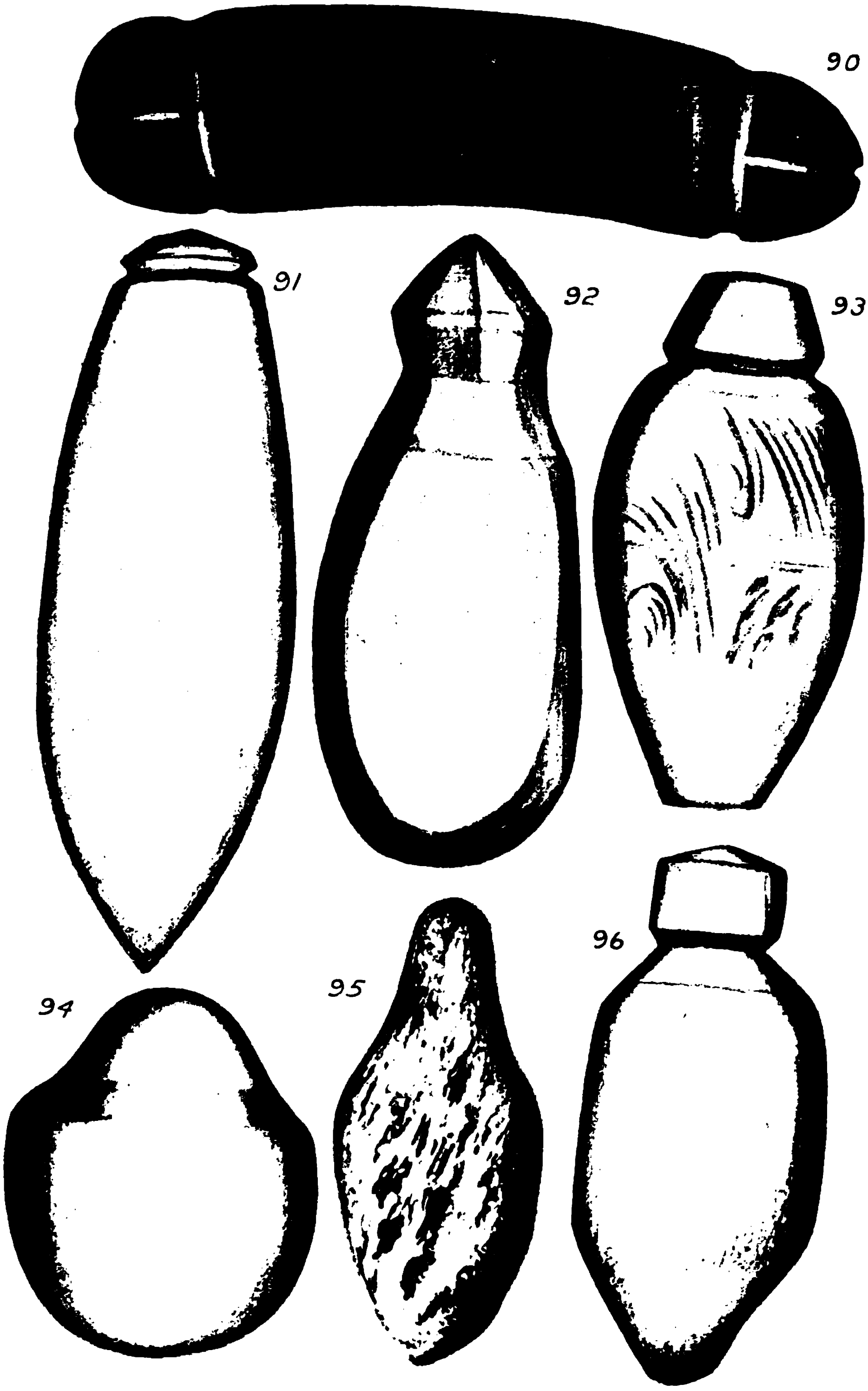
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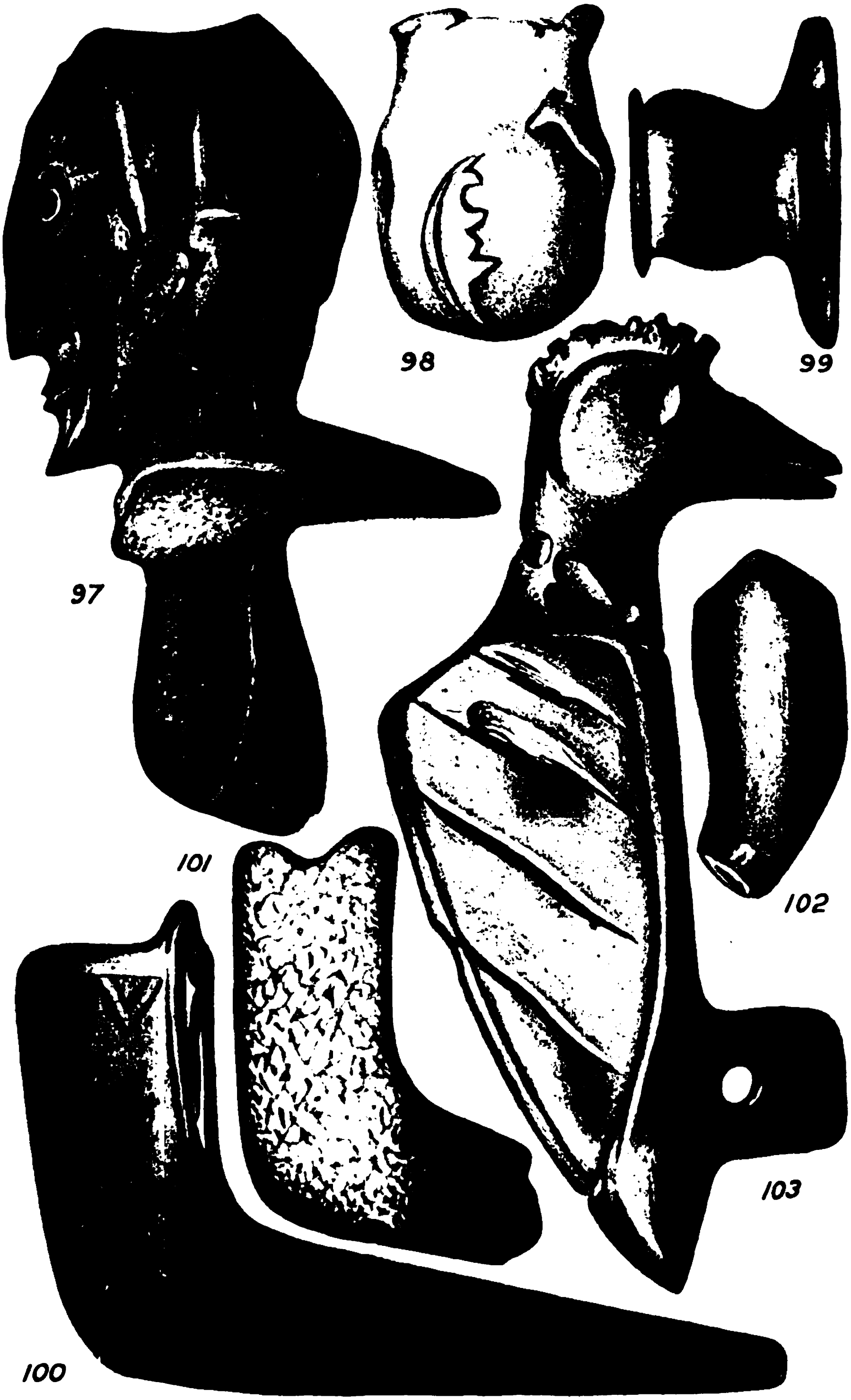
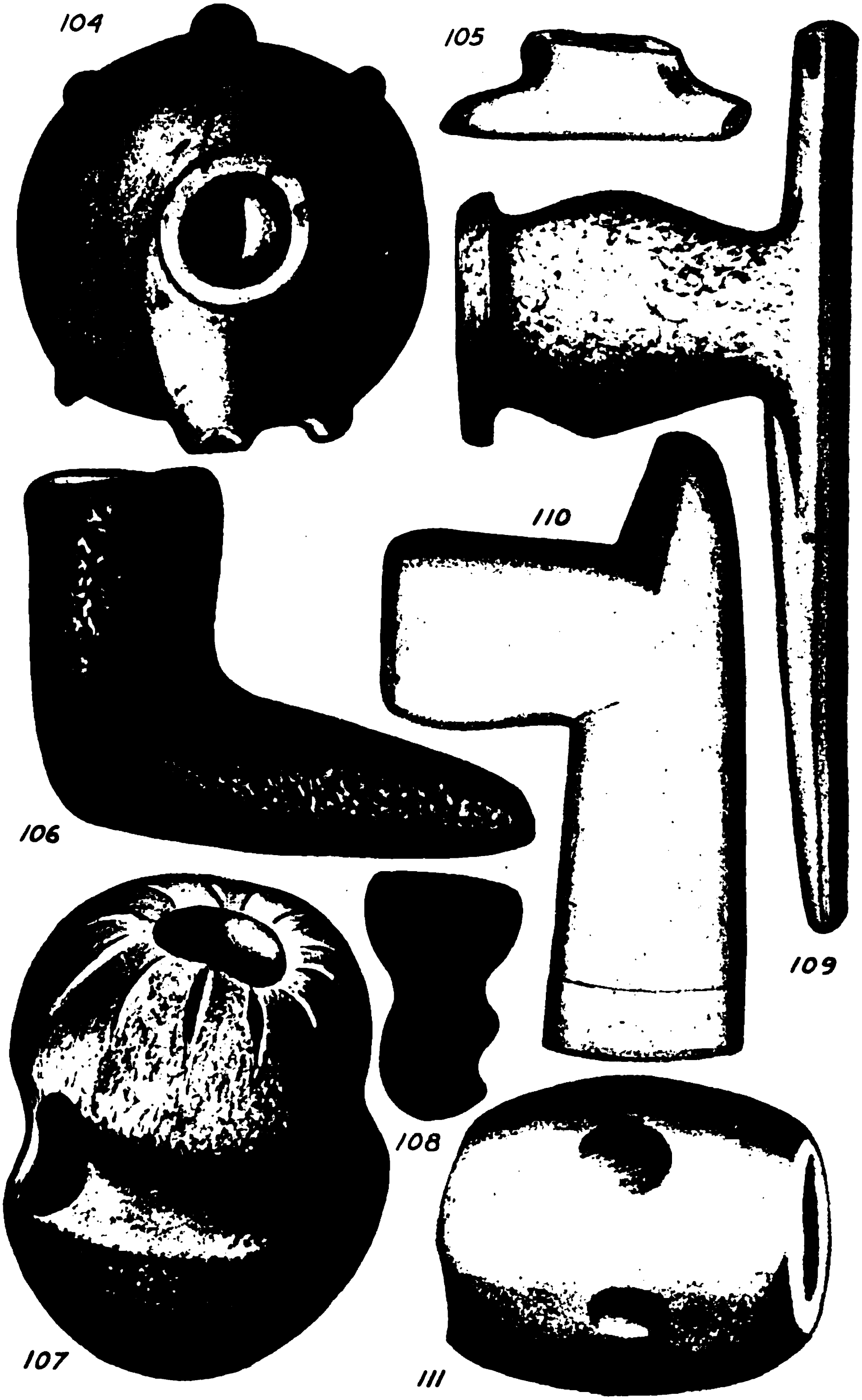

97
98
99
101
102
103
100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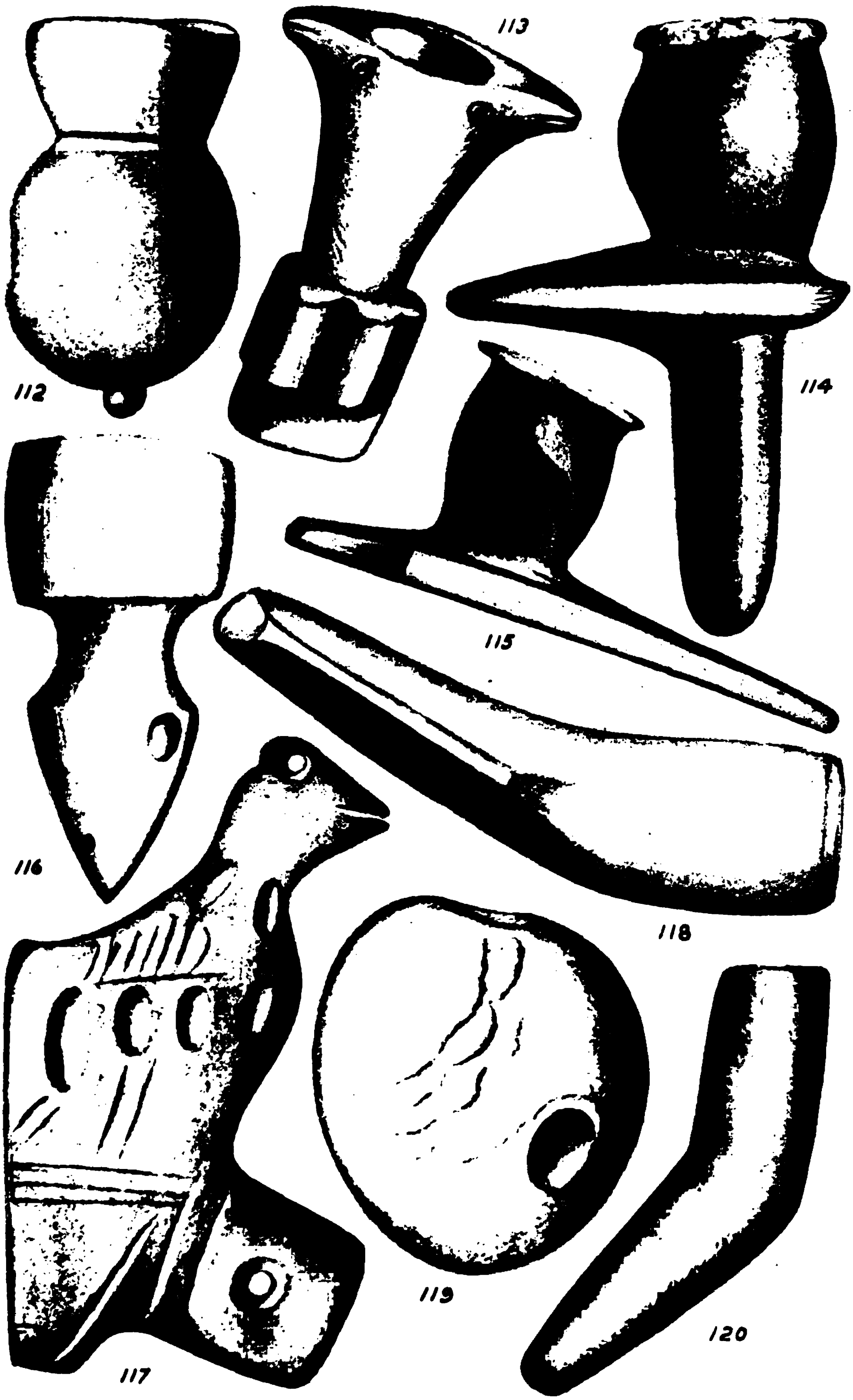
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114
115
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119
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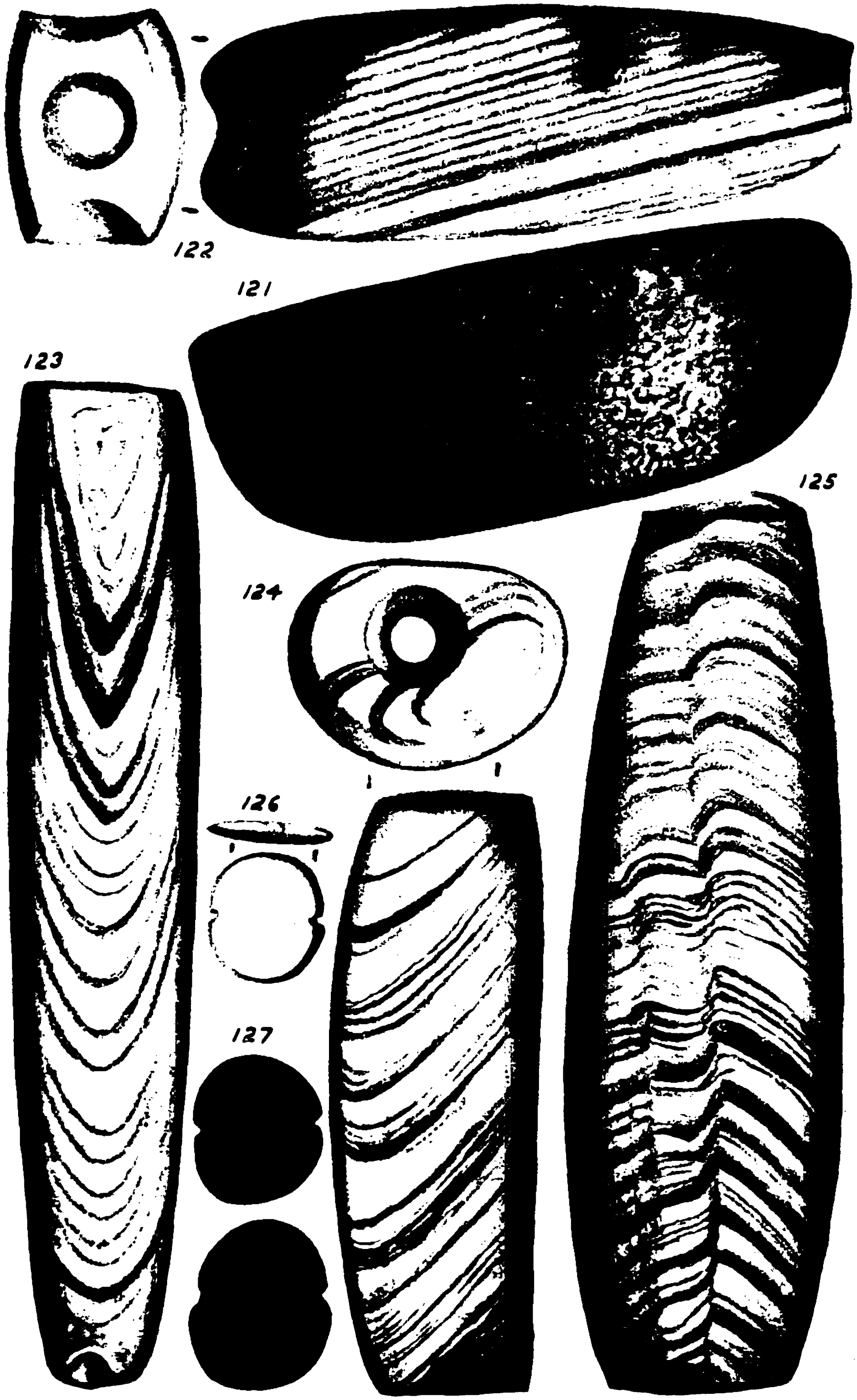
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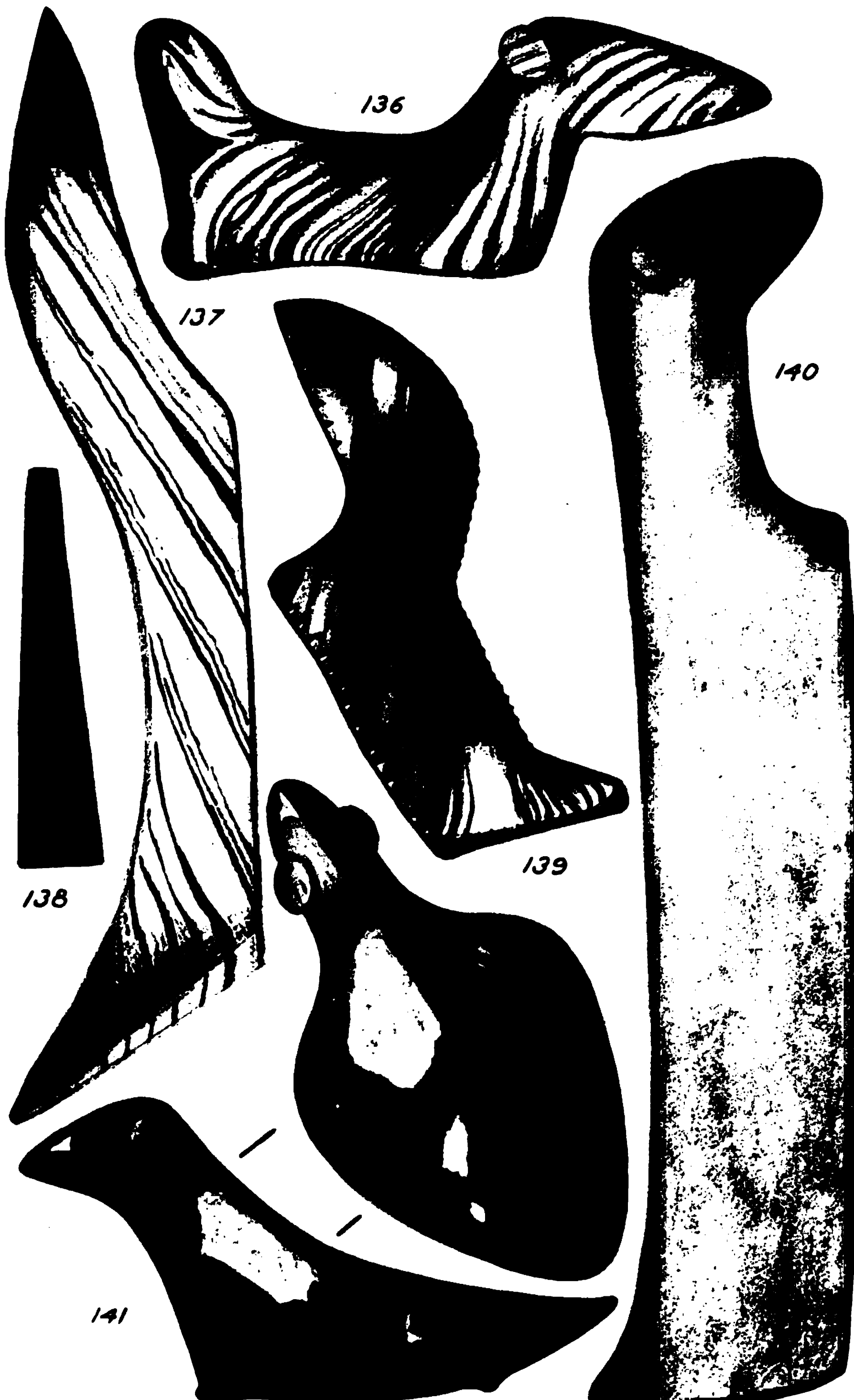
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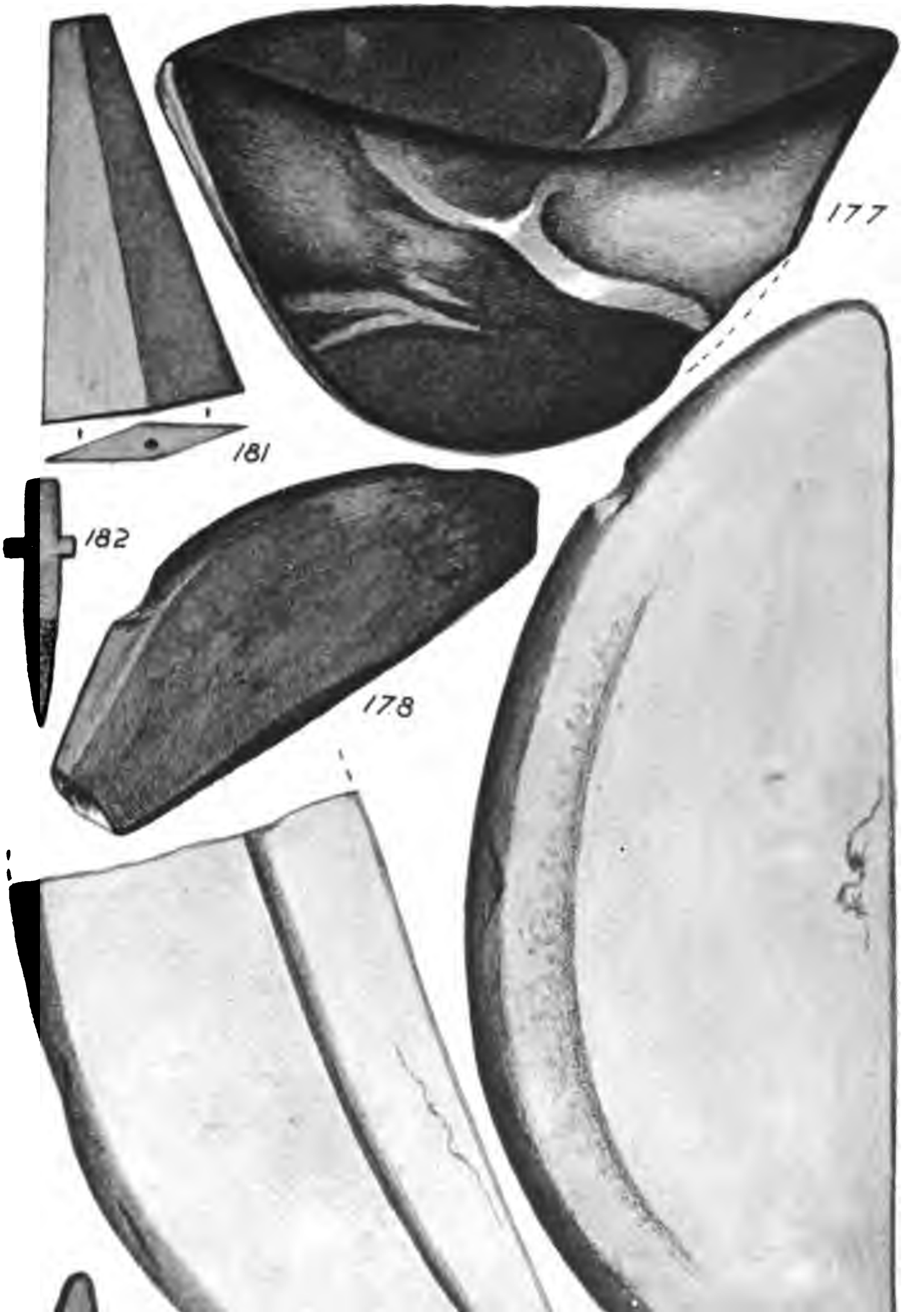
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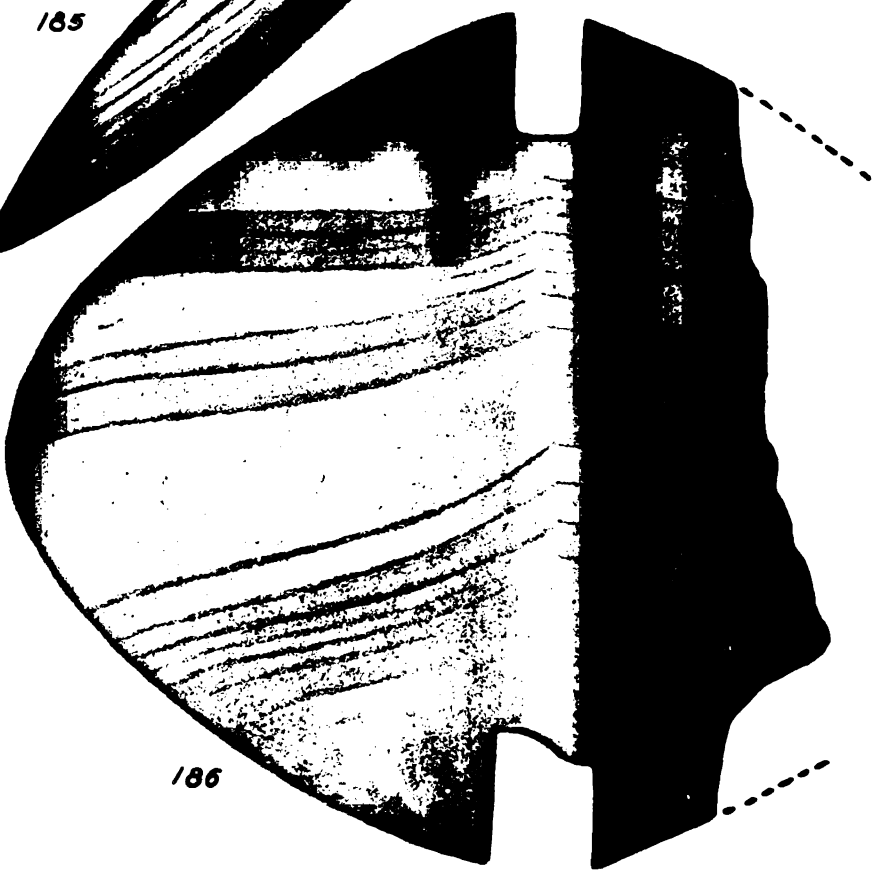
179
180

184

185



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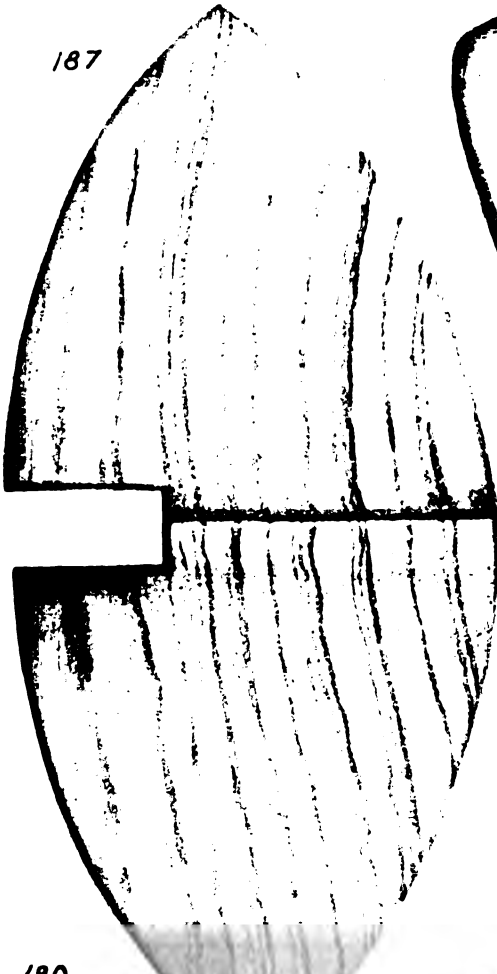

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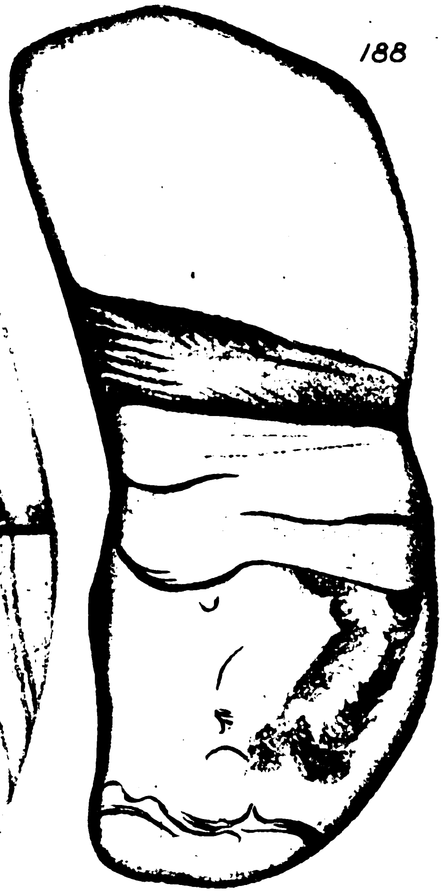

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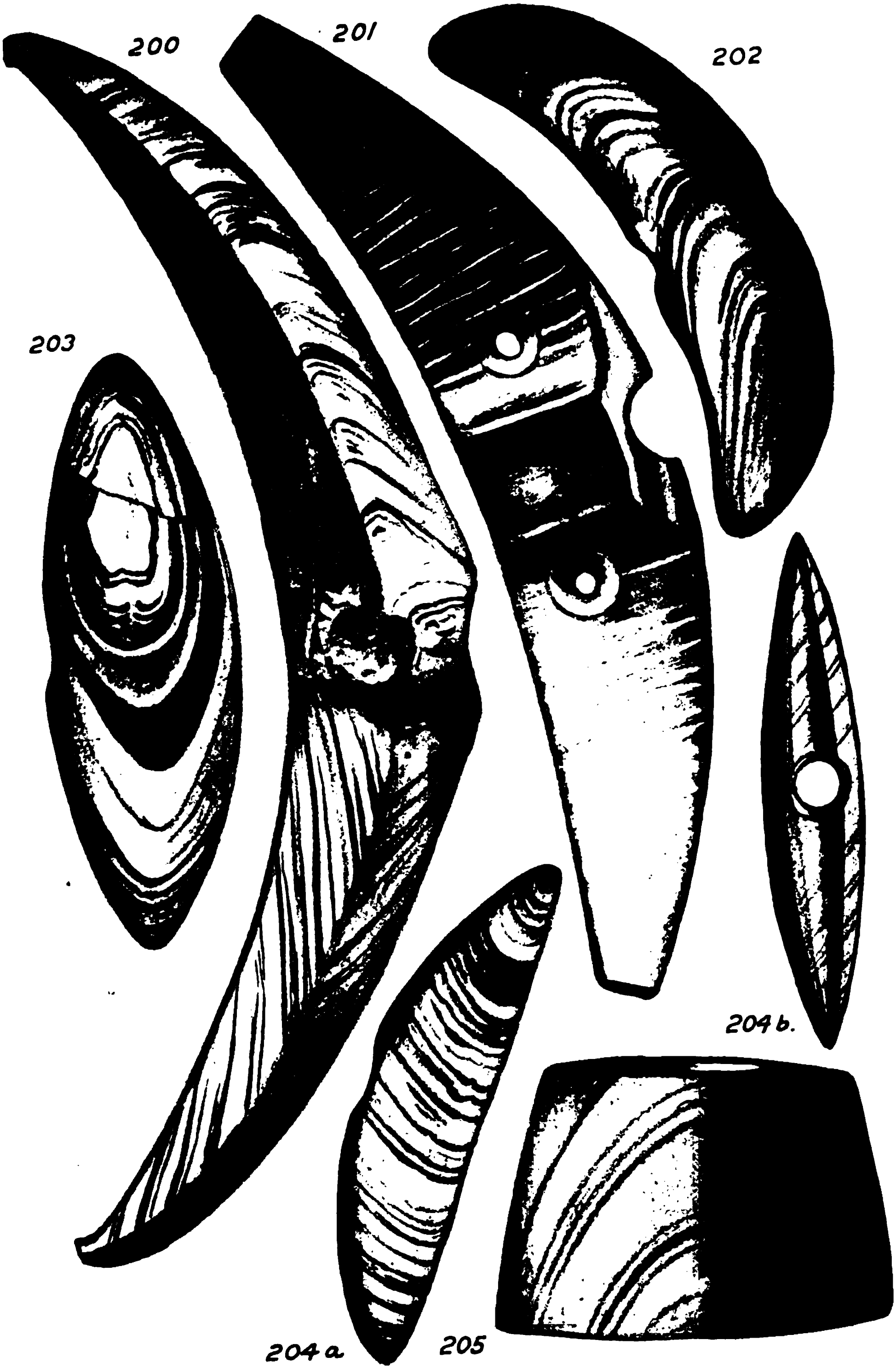
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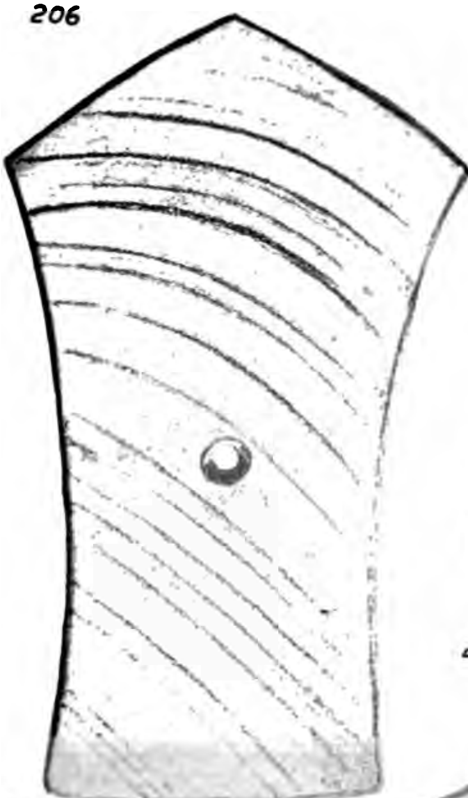
206



207

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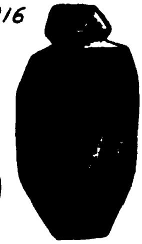
208

210

216



215

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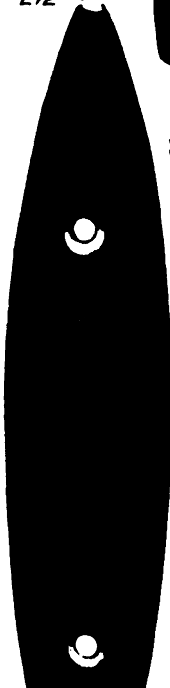

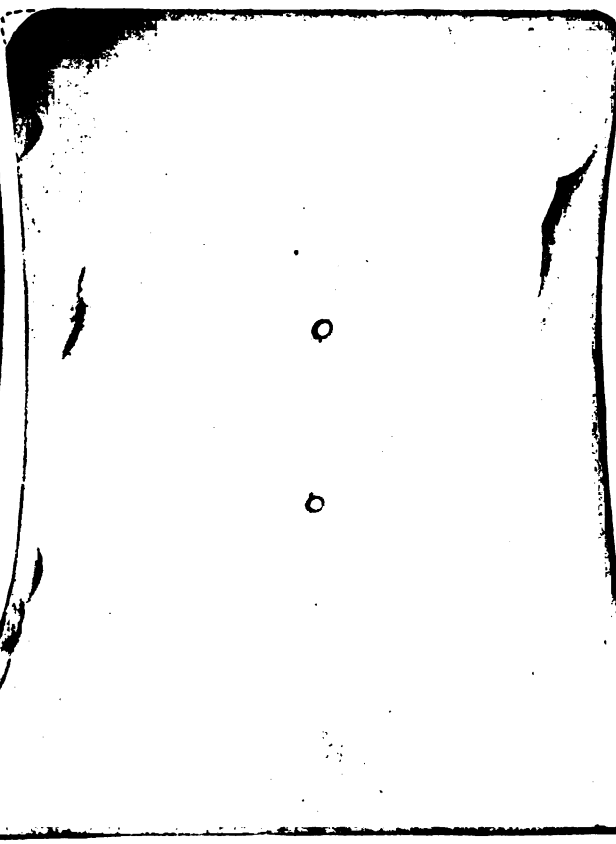

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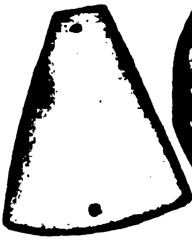

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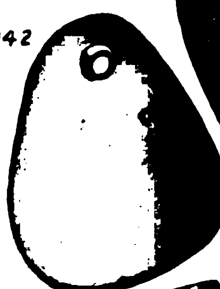

243

244

245

University of the State of New York

BULLETIN

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New York State Museum

VOL. 4 No. 19

NOVEMBER 1898

A GUIDE TO THE STUDY OF THE

GEOLOGICAL COLLECTIONS

OF THE

NEW YORK STATE MUSEUM

BY

FREDERICK J. H. MERRILL, PH. D., *Director*

ALBANY

UNIVERSITY OF THE STATE OF NEW YORK

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CONTENTS

Part 3.

Part 4.

PREFACE

It has been the experience of the Director of the State Museum that a majority of the visitors to the Geological Hall have not had the advantage of an elementary training in geology and therefore do not obtain from the collections such information as they might receive if they fully understood their purpose and value. This statement applies both to the majority of the adult visitors and to the pupils of the various schools who, with their teachers, visit the geologic collections every year. With this fact in view, it seemed important to prepare a Guide to the Study of the Geologic Collections which could be sold at a nominal price and therefore placed within the reach of all who might need it.

As the function of a geologic museum is to aid in the study of geology, the purpose of this guide is to supplement the collections with such general information as cannot be given by cabinet specimens and to direct the visitor to reliable sources for more detailed information.

In 1861, Mr. Ledyard Lincklaen prepared, by direction of the Regents of the University, a *Guide to the Geology of New York and to the State Geological Cabinet*, which was published in the Fourteenth Annual Report of the State Cabinet of Natural History. This report being now out of print and Lincklaen's 'Guide' having been of much use in its day, though now obsolete in many respects, it seemed desirable to replace the latter so far as possible by the preparation of a new guide to the study of the collections.

In this undertaking the attempt has been made not so much to write a new book as to put into convenient form all information necessary to the purpose in view.

In the following pages the general arrangement is similar to that adopted in most of the geologic text books. The introductory matter is newly written and also the larger portion of the chapters on the Archaean and Cambrian rocks. The Cambrian below the Potsdam was not known as such in Lincklaen's time and was not discussed by him. The description given herewith is taken chiefly from the work of C. D. Walcott, Bulletin of the U. S. Geological Survey No. 81. The Palaeozoic strata of New York from the Potsdam to the Catskill were well known to the members of the original geological corps, Hall, Mather, Emmons and Vanuxem and Lincklaen's interpretations of their published results were so satisfactory that in the present work his descriptions of these formations have been used, so far as practicable, with such corrections and additions as were necessary to express our present knowledge.

In making these corrections, the statements of the original corps of geologists and of the later geologists who have worked in New York have been freely quoted.

The descriptions of the Mesozoic and Cenozoic ages have been newly written.

Lincklaen's descriptions of the fossils of New York are not wholly accurate in the light of modern knowledge and in order to save time in revision and the considerable space needed for a proper presentation of the subject, they have been omitted. References are, however, given to the proper authorities and it is hoped that the State Palaeontologist may prepare a handbook on this important subject.

The chapter on economic geology is abridged from Bulletin 15 of the New York State Museum, with some additions.

The illustrations are, to a large extent, new and it is believed that the representation of typical sections and exposures by photographs is more satisfactory than by the more common diagrams.

It is to be regretted that it was not possible to make a series of photographs complete in each geologic series, but no opportun-

ity was afforded for this. The photographs of Dr. Heinrich Ries and Prof. I. P. Bishop were chiefly made for the New York State Museum. The photographs by N. H. Darton are from the collection of the Geological Society of America, and printed through the courtesy of the United States Geological Survey; many of these have already appeared in the report of the State Geologist. The remainder have been secured from various sources.

For many of the general statements concerning the ages and systems acknowledgment is made to the writer's late friend and teacher Dr. John S. Newberry.

To Prof. James Hall, State Geologist, the writer is indebted for numerous facts and conclusions concerning many of the Palaeozoic strata of New York.

As it seemed desirable to provide a pamphlet which could be distributed at cost price to all visitors to the museum who were interested in the study of the collections, the bulletin has been made as small as possible, but it has much outgrown the dimensions originally contemplated.

Since the geologic collections of the New York State Museum are not yet in a state of final arrangement, no detailed reference is made in this bulletin to the museum cases, but the system of labelling adopted is such as to make it an easy matter to refer from the guide to the museum specimens.

It is hoped that this bulletin may, in its function as a guide and supplement to the geologic collections of the State Museum, prove a useful aid to beginners in geology. It aims, through its text, to place within the reach of those interested, a brief synopsis of the geology of the state, and by its illustrations made from photographs, to show the exact appearance of many typical exposures. It is hoped that its readers will receive from it a general idea of the New York formations and will be led to supplement by detailed study of local geology the valuable general text-books accessible to all.

It is assumed that the student before taking up geology has had a good general training in physics and chemistry, without which no proper understanding of the subject can be had. An elementary knowledge of zoology and botany is also indispensable.

FREDERICK J. H. MERRILL

Albany, N. Y.

January 1, 1898

PART 1.

THE SCIENCE OF GEOLOGY AND ITS HISTORY

Geology includes all knowledge of the origin, history, composition and structure of the earth.

Before commencing to discuss geology in its present state of progress, it is desirable to consider briefly its history as a science.

The origin of the world was a matter of interest to the earliest Oriental philosophers no less than to the sages of Greece, and the speculations of these early leaders in thought seem to indicate the possession of some accurate knowledge, but we must date the beginning of geologic science from the period when geologic phenomena were first observed and correctly interpreted. For a record of these earliest geologic studies we are mainly indebted to the industry of Sir Charles Lyell.[a]

Geology began, about 1000 B. C. with the Egyptian priests who observed that the limestones bordering the valley of the Nile had been cut through by erosion and that marine fossils were exposed. In the sixth century B. C. numerous observations on terrestrial changes are ascribed to Pythagoras, and Xenophanes is said to have observed and mentioned the occurrence of various fossils. Aristotle and others in their writings speak of fossil fishes. Attention was also called by Aristotle to the changing distribution of sea and land in certain localities. From that time to the Christian era, history affords many records of observations on geologic phenomena but no attempt was made to reason from the present to the past or to do more than recognize terrestrial changes contemporaneous with man.

Some Arabian writers of the 10th century A. D. are credited by Lyell with accurate observations on the origin of mountains and certain changes of sea level, but not till the 16th century

[a] *Principles of Geology*

did Christian nations give any attention to geologic phenomena, and one of the first men to appreciate and assert the true origin of fossils was Leonardo da Vinci, the famous painter. In his time, public sentiment, influenced by monastic teachings, was so biased that persons who held the opinion that fossils were the remains of living forms, were subjected to persecution. The orthodox view then was, that fossils were freaks of nature produced by the influence of the stars and other mysterious agencies. As various religious interests were supposed to be jeopardized by the more scientific deductions, much animosity was aroused by them.

After 100 years wasted in fruitless discussions on the source of fossil forms, in the beginning of the 18th century the theory occurred to some that the shells which were found in the rocks were relics of the Noachian Deluge and consequently the idea of their organic origin was adopted by many as a confirmation of Biblical history. This new hypothesis lasted for nearly 150 years and those who dared to assert their disbelief in it were exposed to persecution as unbelievers in the Holy Scripture.

During the last half century an invincible array of facts has been developed by diligent scientific workers of many nations in geology, biology, physics, chemistry and astronomy. These facts have been classified into the science of to-day.

ORIGIN OF THE EARTH AND ITS CRUST

The history of the origin of the earth is not found in the study of the earth itself.

Geologic history, properly speaking, begins with the period of the earliest geologic record. But no portion of the first solid crust of our globe is known to be exposed to view nor does it seem likely that any portion of it will ever be revealed. From the kindred sciences of physics, chemistry and astronomy, in many ways, we obtain light upon the origin of the earth prior to the commencement of the geologic record.

The earth is to man, one of the two most important members of a group of celestial bodies held in relation to each other by gravitation, which we call the solar system. The center of this system is the sun, about which revolve the planets with their satellites and the planetoids, and without which as a source of light and heat, no life could exist on earth.

To explain the origin of the solar system the *Nebular hypothesis*[a] was suggested by Swedenborg and Kant and elaborated by Laplace. Although not completely proven it is highly plausible, and answers most of the conditions. According to this hypothesis our solar system originated as a vast nebula, similar to nebulae which now exist, in the form of an immense volume of incandescent gas rotating in space from west to east, of which the limits extended beyond those of the present solar system which is about 5,500 millions of miles in diameter.

As this mass slowly parted with its heat and contracted in obedience to physical laws, its velocity of rotation would increase and in the peripheral or outer portion the centrifugal force would overcome the attraction toward the center, causing it to separate from the central portion in the form of a ring. This ring through unequal condensation would subsequently be broken, its fragments uniting by gravitation into a body revolving about the nucleus and ultimately forming a planet or in one instance a zone of small planets, that of the planetoids or asteroids. This process is supposed to have continued until the various members of the system were set free; the remnant of the much diminished but still intensely heated nucleus remaining as our sun which now has a diameter of 860,000 miles. The primary rings after condensing into planets are believed to have formed secondary rings which subsequently broke and became satellites, except in the case of Saturn which still retains two rings.

Inasmuch as some of the planets near the sun are denser than those more distant, it has been suggested that in the rotation of the primal nebula its components arranged themselves in lay-

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[a]See Young, *General Astronomy*, p. 515-25.

ers of different densities, the rarer substances to some extent occupying the outer portion of the mass.

If, as this hypothesis suggests, our earth is an integral part of the solar system we should expect to find its component elements in the sun and in the other heavenly bodies, and this expectation is confirmed by two distinct sources of information. Chemical analysis of the meteorites which fall to earth shows that these bodies contain many minerals which occur in the earth's crust[a] and that they do not contain any elements which are unknown on earth. Of late the application of the spectroscope to the study of the sun and stars has established the fact that these celestial bodies are largely composed of the elements already known on earth. There are however some lines in the solar and stellar spectra which are not matched by the lines in any terrestrial spectrum.

The conclusion to which we are led by the nebular hypothesis, viz.: that the earth originated as a rotating mass of incandescent gas, is corroborated by its present form, which is that of a spheroid of rotation or of a plastic body which, by rotation, has become flattened at the poles. The difference between the polar and equatorial diameters of the earth is about 27 miles.

Chemical science has established the fact that all forms of matter are composed of one or more of the elementary substances or elements, of which there are 74. These are all found either in the earth's crust, or in its atmosphere; they also occur in the sun, stars and other heavenly bodies. Most of these elements are very rare and do not come to the notice of the geologist. Only 11 are important as constituents of the earth's crust. These more common elements are given in the following table[b] with their proportionate percentages as components of the earth's crust:

Oxygen	50
Silicon	25
Aluminum	10
Calcium	4.5
Magnesium	3.5
Sodium	2

[a] The *crust* is the superficial portion of the earth. [b] Prestwich *Geology*, p. 10.

Potassium	1.6
Carbon	2.4
Iron	
Sulphur	
Chlorine	
Other elements	1
	100

Chemical History of the Earth

In whatever manner our earth came into being, every known fact indicates that in the beginning it must have been intensely heated and in a gaseous condition. In obedience to the laws of matter such a mass would constantly lose heat, and with this loss of heat would come a gain in density, first at the surface only, but gradually progressing toward the center till at that point its constituent matter had reached at least a fluid condition. This may be the present condition of the earth's interior. As an eminent chemist has observed, here commences the chemistry of the earth, and the probable course of events can best be stated by quoting from the words of the late T. Sterry Hunt. As long as the earth's component matter remained in a gaseous condition and its temperature was sufficiently high to prevent the elements from combining, these elements remained separate, but as the temperature was reduced, chemical combinations of these elements became possible, and those would be first formed which were stable at the higher temperature. The oxides of silicon, aluminum, calcium, magnesium and iron were probably among the first substances formed. At some early stage of the earth's existence the bases alumina, lime, magnesia and oxide of iron were probably all combined with silica and that which represented the earth's crust was a fluid mass similar to a lava. The carbon, chlorine, sulphur and water vapor only existed in the primeval atmosphere, which must then have been too acid to permit the existence of any form of life, as it would probably have destroyed animal or vegetable

[a] Chemical and Geological Essays, pp. 37 et seq.

tissue. As the primeval temperature fell, the acid atmosphere would react on the lava-like crust and where the temperature fell below the boiling point of the acids which composed the atmosphere, the water of the globe would be highly charged with salts resulting from the chemical action. With the continued fall of temperature the chlorine and sulphur would be gradually removed from the atmosphere until the composition of the latter became similar to that of the present day, though containing more carbonic acid gas.

This chapter in the earth's history has been so well translated by the aid of chemical science that there is no reason to question its accuracy, but we do not know in detail the history of the massive rocks and gneisses which are now the oldest formations known. It also is probable that a long period of time elapsed between the formation of the primeval ocean and the dawn of life therein. Science has not yet taught us how to measure the length of this period or how to recognize the details of earth-building which occurred in it.

Present Condition of the Earth's Interior

It has been found by observations taken in deep mines and wells that in going toward the center of the earth, the temperature increases approximately at the ratio of 1 degree Fahrenheit to 51 feet of depth.* At this rate, a temperature would prevail at the depth of 50 miles at which all known substances would be fused. On this basis rests the theory of a molten interior, which is corroborated by various volcanic phenomena. All through the historic period and through long geologic ages before, volcanoes have poured out from subterranean sources vast quantities of molten rock. Physicists who have investigated this matter claim that if the interior of the earth were fluid, the crust would yield to the attraction of the moon and that the phenomena of tides would occur within the earth itself. It also appears that the great pressure on the internal mass must keep it in a condition of solidity. In this connection it is pointed out that volcanic phenomena occur along

* The extreme ratios are 1 ÷ 40 and 1 ÷ 80.

lines of mountain making and that probably the outflows of molten rock are due to local relief of pressure by some upward movement within the mountain masses.

Envelopes of the Earth

The earth, besides possessing a solid crust and an intensely heated interior, has two fluid envelopes.

The gaseous envelope or atmosphere, which consists of the air we breathe, surrounds the entire globe.

The liquid envelope, of which the various portions are known as oceans, seas, gulfs, bays, lakes, etc., envelops the globe only in part, the exposed portions of dry land being known as islands and continents.

These two envelopes, under the influence of physical forces, are very active agents of destruction, transportation and deposition in their action on the earth's crust.

The present relations of the envelopes to the continents, the forms of the latter, the causes of climate, the origin of the winds and ocean currents are usually discussed under the head of physical geography. As this subject is not at present illustrated in the State Museum, the student is referred to the many excellent text-books on this science.

COMPONENTS OF THE EARTH'S CRUST, MINERALS AND ROCKS

The earth's crust consists of aggregates of matter which occur in stratified and unstratified masses and are known as rocks. The chemical combinations which form these rocks either singly or in mixture are called minerals. The minerals, therefore, all possess a definite chemical composition which can be expressed by formulæ. Rocks vary in composition, as they consist of one or more minerals. The rocks which are mixtures of several minerals vary in composition as the proportions of their components vary; and it is possible for specimens taken from the same rock mass to differ in chemical composition.

Minerals

Minerals are classified by their chemical composition and by the geometric forms which they assume in crystallization, each mineral having a certain range of forms from which it cannot depart.[a]

These forms are grouped in six systems named as follows: Isometric, Tetragonal, Hexagonal, Orthorhombic, Monoclinic and Triclinic. These systems are characterized by and named in accordance with the number and relation of the axes about which the external geometric faces are developed. In physical relation with these axes are distinct optical properties which can be determined by cutting the minerals in very thin slices and examining these by means of optical instruments. While there are over 700 recognized mineral species, only a small number are important to the geologist as rock making minerals. Of these a few are sometimes found to be the single components of entire rock masses.

Quartz, the crystalline form of silica, is frequently found in large masses in mineral veins and, in its fragmental form, constitutes beds of gravel and sand when loose and, when solidified by cementation, forms conglomerates, sandstones and quartzites.

Calcite and **aragonite** are two crystalline forms of carbonate of lime, the former of which is the chief constituent of many great beds of limestone; the latter is usually deposited by water in forms called stalactites, calcareous tufa, travertine, etc.

Dolomite, the double carbonate of lime and magnesia wholly or in part forms extensive strata of magnesian limestone.

Kaolinite, the hydrous silicate of alumina, is also a very prominent mineral in rock masses. In its pure condition it forms beds of potter's clay, and mingled with various kinds of rock-dust it constitutes extensive strata of clay and shale.

Of the minerals which mingle in the formation of rocks, the most important are quartz, the feldspars and the magnesia-iron silicates.

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[a] For an elementary discussion of crystallography as well as of mineralogy the reader is referred to Dana's *Manual of Lithology and Mineralogy*.

The **feldspars** are silicates of alumina combined with potash, soda or lime. The more common species are: *orthoclase* and *microcline*, silicates of alumina and potash.

Albite, silicate of alumina and soda.

Anorthite, silicate of alumina and lime.

Oligoclase, *andesite* and *labradorite*, which contain both lime and soda, and are intermediate between albite and anorthite.

In crystallization orthoclase is monoclinic, the others named are triclinic.

The triclinic feldspars are usually called *plagioclase* in technical rock nomenclature, and are referred to collectively by this term.

The **magnesia-iron silicates** are classified in three principal groups, the amphiboles, pyroxenes and micas.

The *amphiboles* are monoclinic and comprise hornblende, actinolite and tremolite.

Hornblende is a silicate of alumina, iron, lime and magnesia; it is very tough and somewhat fibrous in fracture, its color varies from dark green to blackish green. This is a very important constituent of granites and other crystalline rocks.

Actinolite is a fibrous variety, generally light green in color and containing less alumina.

Tremolite is usually white and contains but little iron and no alumina. It occurs generally in crystals scattered through crystalline limestone.

Asbestus is a finely fibrous tremolite.

The *pyroxenes* have very nearly the same chemical composition as the amphiboles and are also monoclinic but crystallize with a different prismatic angle.

Augite, which corresponds closely to hornblende in composition and resembles it in many ways, is an important constituent of many eruptive rocks such as diabase, basalt, etc.

Pyroxene is lighter in color than augite and similar to actinolite in composition.

Diopside corresponds closely to tremolite in composition and like it, occurs in limestones.

Besides the above species which are monoclinic, there is an important group of orthorhombic pyroxenes.

These are hypersthene, bronzite and enstatite.

Of the *micas* there are many species. The most important rock-making mica is *biotite*, a silicate of alumina, potash, iron and magnesia. It is brownish black in color and is abundant in the granites and gneisses.

Muscovite, a silicate of alumina and potash, is less important as a rock mineral but is valuable commercially for its thin transparent plates used in stove doors, etc.

The hydro-micas, *margarodite* and *damourite*, are similar to the true micas in composition but contain water.

Olivine, or *chrysolite*, is a silicate of iron and magnesia which occurs usually in small crystals or grains in igneous rocks. It is pale green in color.

Olivine is of special importance because from it, by decomposition, is derived a large proportion of the serpentine rocks.

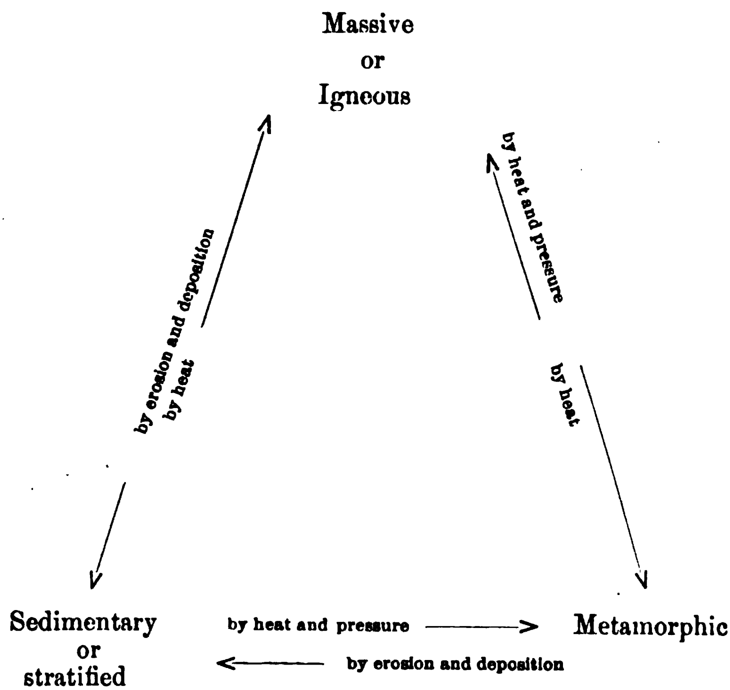
Besides these few minerals which are essential components of rocks and usually by their presence or absence determine the rock species, there are others which are only accessory and while of frequent occurrence do not so invariably affect the name of the rock in which they occur. Such are garnet, zircon and staurolite.

In addition to the rock-making minerals are those which occur in large masses in other rocks and have a commercial value. Such are corundum, or emery, the ores of iron, e. g. magnetite, hematite, spathic ore; coal, asphalt, halite or rock salt, gypsum, the ore of lead and silver, galenite; the ore of copper and gold, chalcopyrite and graphite or black lead.

Of rarer occurrence and great commercial value are the gems diamond, ruby, sapphire, emerald, etc. None of these are found in New York.

Rocks

These are the materials of the strata and other masses which form integral parts of the earth's crust. They may be classified as massive or igneous, sedimentary and metamorphic. The relations of these three natural groups may be shown by a triangular diagram, as follows:



This is meant to show that an igneous rock may, by erosion, be reduced to sediment and laid down in beds, or by heat and pressure may be metamorphosed from its original massive condition and become schistose. A sedimentary rock may also pass through the metamorphic condition, become fused and enter the igneous state. A metamorphic rock may arrive at the igneous condition by heat and pressure, or may become sedimentary through erosion and deposition.

Igneous rocks

The igneous rocks are very numerous, but may be classified in a few groups by mineral composition and texture. The texture indicates usually the conditions of their cooling. If the cooling occurred at a considerable depth, the process was gradual, crystals of the component minerals formed slowly and freely, and the resulting texture is coarse. If the cooling was in the open air, as in a lava bed, the process was more rapid; there was not sufficient time for crystals to form, and the resulting texture is fine or glassy.

The first class is called *plutonic*, the second *volcanic*. Plutonic rocks abound in the regions where old geologic formations are exposed, since there, either the intrusions did not reach the surface or the surface material which cooled as lava was removed by long erosion, and we see only those parts which were deeply covered while cooling. Examples of this are seen in the Palisades of the Hudson; the granite mountains, Anthony's Nose, Storm King, Breakneck and other peaks of the highlands, and in Mt. Marcy, Whiteface, etc., of the Adirondack chain. The volcanic rocks are chiefly exposed in regions of the newer formations because of the deep-seated plutonic masses have not yet been brought to view by erosion. The only good exposure of this character in New York is the mass of red porphyry or trachyte at Cannon's Pt., near Essex, on Lake Champlain.

This statement involves the theory that every volcanic mass has beneath it, or connected with it, a plutonic mass of the same general chemical composition.[a]

The names of a few important igneous rocks and their essential compositions are given below according to the classification of Rosenbusch.[b]

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a The accurate classification of rocks dates from about 1873, with the development of methods of study with the microscope. Most of the older books in English are much behind the present German standard of progress.

b Mikroskopische Physiographie der Mineralien und Gesteine.

PLATE I.—To face page 124.

H. Ries, photo.

GRANITE DYKE IN HUDSON RIVER SCHIST, SOUTH SIDE OF 192D ST., NEW YORK CITY.

PLATE II.—To face page 124.

Granite.

Limestone.

H. Ries, photo.

IGNEOUS GRANITE ON LOWER SILURIAN LIMESTONE, 192D ST., NEW YORK CITY.

PLATE III.—To face page 124.

H. Ries, photo.

EXPOSURE OF SERPENTINE ROCK, HOBOKEN, N. J. DERIVED FROM THE CHEMICAL ALTERATION OF AN IGNEOUS ROCK.

PLATE IV.—To face page 124.

H. Ries, photo.

PALISADES OF THE HUDSON RIVER, SEEN FROM HASTINGS; WESTCHESTER CO. TRIASSIC DIABASE OVERLYING SANDSTONE, WHICH IS CONCEALED BY THE TALUS.

Orthoclase and hornblende		Plagioclase and hornblende		Plagioclase and augite		Plagioclase and hypersthene
With quartz	Without quartz	With quartz	Without quartz	With olivine	Without olivine	
			Plutonic			
Granite	Syenite	Quartz diorite	Diorite	Olivine diabase	Diabase	Norite
			Volcanic			
Quartz porphyry rhyolite	Trachyte	Quartz porphyrite	Andesite porphyrite	Basalt	Augite andesite	Hypersthene andesite

Sedimentary rocks

These are, for the most part, deposited in water, and are of three classes, mechanical, chemical and organic.

The principal examples of these are:

Mechanical

1 Sand, gravel, sandstone and conglomerate. These are the debris of rocks containing quartz.

2 Clay and shale. These are formed of the debris of feldspar and the residuum from impure limestone.

3 Tuffs. Deposits of loose volcanic materials.

Chemical

4 Rock salt (chloride of sodium), deposited by evaporation from bodies of salt water.

5 Gypsum (sulphate of lime), deposited by evaporation from bodies of salt water. All sea water contains sulphate of lime.

Organic

6 Limestone, deposited in oceans from debris of marine animals, corals, mollusks, etc.

7 Coal, formed from accumulations of vegetation in marshes.

Metamorphic rocks

These have been subjected to heat and pressure usually in the presence of moisture, and have lost their original form and structure. They include the following:

Gneiss, which ordinarily has the same composition as granite,[a] with a foliated or schistose structure.

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[a] In modern usage the word *gneiss* designates only the schistose or foliated structure and any massive rock made schistose by metamorphism is called gneiss.

Schist, mica schist, hydromica schist, talcose schist, etc. Various members of the mica group play an important part in the schists.

Slate. This is mainly shale hardened by metamorphism and rendered fissile by pressure. The roofing slates are good examples.

Crystalline limestone. This is sedimentary limestone made crystalline by heat and pressure.

All kinds of igneous rocks may become schistose by metamorphism and then receive names indicating their composition and structure.

HISTORIC GEOLOGY

Historic geology treats of the succession of geologic deposits and is based on the study of sedimentary rocks.

It is estimated that the geologic series consists of about 100,000 feet or 20 miles thickness of sedimentary strata. These are beds of sediment chiefly formed by successive invasions of the sea and the transportation and deposition by it of debris detached from the rocks of the mainland by rain, frost, rivers and the ocean waves.

It has been estimated that about 99% of all rocks are sedimentary, and although some of these were formed in fresh water, probably the larger part of the sedimentary rocks were deposited in the ocean. It has consequently been said that 'the sea is the mother of continents.' On our Atlantic coast, as elsewhere, the ocean is both a destructive and a formative agent. As the soundings show, the loose materials washed from the land are spread out about 100 miles from the shore line in a broad, sloping plain of sand and mud. In such submarine deposits, when uncovered by the ocean's retreat, we find the remains of mollusks, fishes and other marine forms of life. Besides, land animals are often drowned and their bodies are carried out to sea and covered with sediment, leaves fall on the water and sink to the bottom. Therefore, in rocks formed in the sea we sometimes find remains of land animals and plants, besides the marine forms which we expect. The unceasing action of

rain and frost, rivers, waves and currents through all time has led to the deposition of a succession of strata which on the whole are unbroken in their sequence, though they have varied so much in the areas of their deposition that in no region do we find the series complete. There has been a break of continuity in those areas which for a time were elevated above the sea, but the continuity of the geologic series has always been maintained in one area or another. Contemporaneous strata are found only in those areas which are simultaneously depressed and which were submerged during the same time.

Contemporaneous strata may differ widely in composition owing to differences in material and the conditions of their deposition. Thus the Potsdam sandstone in northern New York is contemporaneous with a limestone in Saratoga and Dutchess counties.

As a result of the alternating invasions and retreats of the ocean over the land, we find in various geologic systems what is known as a trinity of formations,[a] viz. a base consisting of *sandstone* or *conglomerate*, a center consisting chiefly of *limestone* and a summit of *shale* or *mud stone*.

The cause of this alternation is not fully known. The sandstones and conglomerates are usually solidified beach and shoal water deposits. The shales are solidified sea bottom deposits consisting of the finer material carried from the shore by waves and currents and also of sediment carried into the sea by rivers.

The limestones were probably formed in many cases as at the present day, in warmer waters, which permitted the luxuriant growth of corals, mollusks and other marine invertebrates which have external skeletons composed of carbonate of lime. In New York there were coral reefs in the Trenton, Niagara and Corniferous periods. Whether corals in Palaeozoic time required the same warm temperature of water as at the present day, we do not know.

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[a] Geikie's *Text Book of Geology*, IIIrd Ed. p. 454.

DYNAMIC GEOLOGY

Under this head there is only enough space to enumerate the different agencies which are productive of geologic change or are associated with it. For a detailed discussion the student is referred to the text-books.

The dynamic agencies of geology may be roughly classified into two groups: *hypogene* or subterranean and *epigene* or superficial. Under the first head the principal agencies are volcanoes, earthquakes, secular changes of level and metamorphism. These, as their group name indicates, are chiefly controlled by forces that work beneath the surface of the earth; the second or epigene group comprises those which are chiefly manifest upon the earth's surface. First among these is the air. Air in motion or wind, is of marked importance as an agent of transportation as manifested in sand dunes, at places where deposits of fine sand occur, chiefly on the sea shore and in deserts.

A more active agent than air is water. By the action of its terrestrial forms, rain, snow and ice and by the cumulative forms of these, rivers and glaciers, the highlands are reduced and vast amounts of material are transported by the aid of gravity.

The oceanic waters are agents of destruction, transportation and formation. Waves beat upon the land and loosen fragments from the rocks upon which they beat. These fragments, carried out within reach of the oceanic currents, are borne along and drop to the bottom forming sand bars and other sub-aqueous deposits. Lastly, animal and plant life, both terrestrial and aquatic, are formidable agents of change, both destructive and constructive.

Resumé

Hypogene or subterranean agencies

Volcanoes
Earthquakes
Secular change of level
Metamorphism

Epigene or superficial agencies

Air

Water { terrestrial, oceanic

Erosion and sedimentation

Animal and plant life.

PALAEONTOLOGY

In studying an extensive series of geologic formations from bottom to top, we find that through geologic time there has been a progressive advance in the development of animal and plant life as well as a change of genera and species. Forms that are abundant at one horizon seem to have ultimately given up the battle for existence and disappeared, their place in nature being filled by others. So by careful comparison of the animal and vegetable remains found in the different systems and groups and in the minor sub-divisions of the groups, we come to regard the fossils as labels by which we may know the age of strata. While there are some persistent types which pass from one system to another without material change, we find that the life characteristics of each group are essentially distinct. It is therefore important for the field geologist who is studying the formations above the Archaean to be familiar with their fossils in order to determine the horizons accurately.

In the older formations, plants were few and elementary and, containing but little mineral matter, have not been well preserved so that we depend more on fossil animals than plants for the identification of the Palaeozoic strata. From the Mesozoic on, impressions of land plants are more abundant and become of much value in palaeontology.

As shown by the fossil remains discovered in rocks of different ages, the development of animal life has been a gradual one, but we are not yet acquainted with any formation which contains the earliest forms of life. We begin our study, as it were, at a somewhat late period of life development, the Cambrian, for the fossils of the pre-Cambrian rocks are not yet well known. Somewhere

and at sometime, an opportunity will be afforded for the study of pre-Cambrian life. West of the Rocky mountains, stratified deposits of great thickness are known beneath rocks of Cambrian age and these may, in time, when carefully searched, yield an abundant fauna.

Development of Life

ANIMALS

In classifying the animal kingdom, we find that by the presence or absence of an important feature it is possible to place most of the forms in two great sub-kingdoms: the invertebrates and the vertebrates; those without a backbone and those possessing one.

The animals without backbone are considered lower in the scale of development, as they have, in general, less intelligence and fewer resources. They are usually dependent for protection on an external skeleton or armor which encloses their soft bodies.

The vertebrate animals are, in general, characterized by relatively higher intelligence and have, at their command, more ways of protecting themselves and securing a living. The soft parts of their bodies are built around a bony skeleton and they depend for self protection more generally on their activity and intelligence than upon mere mechanical means of protection such as shells or armor.

Among the invertebrates the cuttlefishes were and are still the most highly developed type in regard to size and power though the crustaceans are considered to be more highly organized; among the vertebrates, man is supreme.

As we do not know the whole history of life development, we cannot show accurately in a diagram or scheme the relations of the different groups. The older arrangement which is still used in many text-books of geology is as follows:

Classification of Animal Life

Sub-kingdoms		Classes	Examples
Vertebrates		Mammals	Man, cow, horse, sheep, dog, whale, etc.
		Birds	Owl, turkey, hawk, sparrow, etc.
		Reptiles	Serpents, lizard, tortoise
		Amphibians	Frog, toad, salamander
		Fishes	
Invertebrates	Mollusks	Cephalopods	cuttlefish
		Pteropods	
		Gasteropods,	snail, etc.
		Lamellibranchs,	clam, oyster, etc.
		Brachiopods	
		Tunicates	
		Bryozoans	
	Articulates	Crustaceans,	trilobite, crab, lobster
		Insects	
		Worms	
	Radiates	Corals, starfish, etc.	
	Protozoa	Sponges, foraminifera, etc.	

This classification though time-honored and convenient in elementary palaeontology, has been superseded among zoologists by one slightly different, which indicates more truthfully the relations of the various groups or branches in point of development.

The following diagram by Packard[a] may be taken as representing the modern view.

Sub-kingdoms of animal life

VIII Vertebrata
Fishes to man

VII Arthropoda
Crustaceans and insects

VI Mollusca*
Snails, clams and oysters, cuttlefish

V Vermes
Worms

IV Echinodermata
Sea urchins, star fish

III Coelenterata
Corals, jelly fish, etc.

II Porifera
Sponges

I Protozoa
Foraminifera, polycystines, etc.

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a *First Lessons in Zoology*, p. 10

* The Brachiopods, Tunicates and Bryozoans are now separated from the Mollusca into the group of Molluscoida.

PLANTS

The following classification will give a general idea of the development of vegetable life.

4 Phanerogamia or Spermatophyta	Angiosperms	Dicotyledons or Exogens	Most of the forest trees and shrubs, oak, ash, etc.
		Monocotyledons or Endogens	Palms Lilies Grasses, etc.
	Gymnosperms	Conifers, pine, spruce, etc. Cycads	

Cryptogamia	3 Acrogens or Pteridophyta	Lycopods or Club mosses Ferns Equisetae or Horsetails	
	2 Anogens or Bryophyta	Mosses Liverworts	
	1 Thallogens or Thallophyta	Fungi	Mushrooms, etc.
		Lichens	
		Algae	Sea weeds Diatoms

This classification is not now used in the more modern books on botany, but is followed in most of the text-books of geology.

PHYSIOGRAPHY AND STRUCTURE

In order to appreciate the position and attitude of the geologic formations in New York, it is necessary to form a mental picture of its physiography. For the purpose of reference the following terms may be adopted to describe the principal physiographic divisions of the state:

I The Adirondack upland, comprising the Adirondack mountain region and the adjacent territory.

II The southern upland; west of the Hudson river and south of the line of the Mohawk valley prolonged to Buffalo.

III The Highland-Taconic range; the mountains of granite crossing the Hudson river near West Point, and those of mica schist along the New England border.

IV The Central valley, consisting of the valley of the Mohawk and the low land extending from it to the Niagara river.

V The Hudson-Champlain valley, including the basin of Lake Champlain.

VI The Coastal plain, including Long Island and southern Staten Island.

As the geologic map shows, the principal Palaeozoic outcrops in New York have three principal positions and directions:

1) In zones encircling the Adirondack upland. These zones are much disturbed locally by faults, so that the outcrops are irregular. 2) In lines parallel with the Highland-Taconic range. This mountain axis has a northeast direction in the Highlands of the Hudson, changing gradually to north in the Champlain valley, where the Green mountain uplift is tangent to that of the Adirondacks. 3) In east and west lines across the southern upland from Albany county to the Niagara river and Lake Erie, locally intersected by river and lake valleys.

That portion of the state bordering on the Pennsylvania boundary is a high plateau, with summits about 2000 feet above tide. Its surface slopes gradually northward toward Lake Ontario and its component rock strata slope or dip southward.

From this it results, that, as we go southward from Lake Ontario, we ascend in vertical altitude and also in the geologic column. Our youngest Palaeozoic rocks, which are Lower Carboniferous, are near the Pennsylvania boundary.

These physiographic features are well shown on the accompanying relief map of New York.

For a detailed discussion of the geography of New York see Examination bulletin 11, University of the State of New York, by Wm. Morris Davis.

GENERAL CLASSIFICATION OF GEOLOGIC TIME AND STRATA

It must be realized by the student at the outset that all classification is to some extent arbitrary. There was throughout the earth as a whole a continuous process of erosion and sedimentation and a continuous chain of life. Locally, through changes of level, sedimentation was varied and life interrupted from time to time. For convenience in discussion, a scheme of arrangement has been adopted which is based on the more conspicuous of these breaks in life and sedimentation.

According to the classification most generally accepted, the principal divisions of the geologic time scale are called *aeons* or *times* and designated by the following names which are based on the principal features of life development:

Cenozoic, latest time, characterized by forms closely related to those of the present day.

Mesozoic, middle time of life development.

Palaeozoic, early time; ancient forms of life well developed.

Proterozoic or **Agnotozoic,** life not well known as yet.

Archaean time of the most ancient rocks with only suggestive traces of life.

The *aeons* are subdivided into *periods* as follows:

Æons	Periods	Prevailing types of animal life
Cenozoic	Quaternary or Pleistocene Tertiary	Mammals
Mesozoic	Cretaceous Jurassic Triassic	Reptiles
Palaeozoic	Carboniferous Devonian	Fishes
	Upper Silurian Lower Silurian or Ordovician	Mollusks
	Cambrian	Crustaceans
Proterozoic or Agnotozoic	Keeweenawan Huronian	Not known in New York
Archaean, not yet sub-divided	Laurentian	

The rock formations of the aeons are called *series* and of the periods, *systems*.

The systems may be described in general terms as those divisions of the series which are world-wide in their differentiation. The subdivisions of the systems which are called *groups* are chiefly local and variable. The groups are divided into *stages*.

PART 2.

GEOLOGIC FORMATIONS OF NEW YORK

New York is the mother state in geologic nomenclature, and the names chosen by its early corps of geologists have been adopted in a large degree throughout the whole of the United States. It has moreover, exposed within its borders, a more complete and extensive series of the formations below the Carboniferous and above the base of the Cambrian than any other state in the Union. It is therefore evident that a complete and representative collection of the New York rocks is of no small importance and the description of its formations is a matter of much interest.

SYNOPSIS

System	Group	Stage
Carboniferous		Olean Conglomerate of Allegany and Cattaraugus counties. This is the Pottsville Conglomerate of Pennsylvania.
Devonian	Chemung-Catskill	
	Portage	Portage sandstone Naples beds Gardeau shale and sandstone Cashaqua shale
	Hamilton	Genesee slate Tully limestone Hamilton { Encrinal limestone Ludlowville shale } Marcellus shale
	Corniferous	Corniferous limestone Onondaga limestone Schoharie grit Cauda galli grit
	Oriskany	Sandstone

System	Group	Stage
Upper Silurian	Lower Helderberg	Upper Pentamerus limestone Delthyris shaly limestone Lower Pentamerus limestone
	Salina	Shale, limestone, salt and gypsum
	Niagara	Niagara shale and limestone Clinton sandstone, limestone and shale
	Medina	Medina sandstone Oneida conglomerate
Lower Silurian	Hudson river	Pulaski and Lorraine shales Frankfort slate Utica slate
	Trenton	Trenton, Black river, Birdseye, Chazy limestones
	Calciferous	
Cambrian	Potsdam	Sandstone and limestone
	Acadian	
	Georgian	Quartzite and slate
Archaean		gneisses and Granites

ARCHAEAN

This name was proposed by Prof. J. D. Dana to include those ancient crystalline rocks, which in nearly all countries are seen to underlie the oldest fossiliferous strata.

Although various subdivisions and classifications have been proposed at times, in the light of present knowledge their accuracy is uncertain and they will not be mentioned here.

The Laurentian rocks of Canada may be regarded as types of the Archaean.

In New York, as elsewhere, this system is represented by a series of crystalline rocks including gneiss, granite, diorite and norite. Crystalline limestone is often associated with them, but we do not know whether it should be regarded as truly Archaean. These rocks are exposed where uplifts from below in early time raised them up to form islands in the Palaeozoic seas, or in later time have caused them to break through the overlying strata. An instance of the latter occurs at Littlefalls, where the hard, red and gray granite has been forced up in a dome and appears

PLATE V.—To face page 138.

J. N. Nevius, Photo. PRECAMBRIAN GNEISS. MOHAWK VALLEY, LITTLEFALLS, HERKIMER CO.

in the gorge of the Mohawk protruding through the Hudson river shale and Trenton limestone.

Beneath the metamorphic rocks of the Archaean and intersecting them, are found what are known as Plutonic[a] rocks, the peculiarity of which is, that they are not found in layers or strata, but in solid masses, and appear to have been forced up from below in a plastic condition. They form the central mass of the Adirondacks, and large areas of them are found in the Highlands and in many parts of New England. They were once generally called 'primary' or 'primitive', as it was believed that they were the original crust of the earth, first formed in the cooling of its melted mass, but it is now doubted whether, if such a crust exists, it can be identified, and many geologists think that most of the granites and other plutonic rocks are only re-melted and altered forms of older ones. That many such masses are so, is certain; and whether we can find any which are portions of an original crust of the globe, is at least very doubtful.

Containing no fossils, these rocks have their chief interest in their value for economic uses in building and other purposes, and in the cabinet specimens of the minerals which they so often contain.

The Archaean rocks cover two separate tracts of country in this state, one in its southeastern part known as the Highlands; the other lying in the central portion of the great Adirondack wilderness.

Various kinds of rocks are mingled over most of these areas, seeming often to change or gradually pass into each other. The metamorphic masses of gneiss, etc. are more fully exposed (as a general rule) around the edges of the tracts, where they pass under the lower strata of fossiliferous rocks; while the granite, hypersthene and other plutonic masses are more fully developed near the centers of these areas and among the highest of the mountains.

Throughout the Archaean districts there are many dykes, or veins of trap or other igneous rock penetrating masses of a different character. Not infrequently, a mountain or hill shows

[a] Plutonic, from Pluto, king of the infernal regions in Pagan mythology.

such dykes cutting across or through it for a long distance, and to an unknown depth. These represent cracks or clefts by which the country has been riven and which have been filled by the rise of melted matter from below. They are all sizes, from half an inch to 100 feet or more in thickness.

Plutonic dykes are not confined to Archaean regions. Dykes of granite are seen in many places on New York island, penetrating in every direction the Lower Silurian mica-schist which forms the masses of its territory.

These are examples of a phenomenon frequently observed, viz.: a plutonic rock penetrating strata of Paleozoic or later age. They are similar in their origin to the out-flows of lava from volcanoes.

A prominent example of a late plutonic intrusion is seen in the 'palisades' of the Hudson, which is described under the Triassic rocks.

The plutonic and metamorphic rocks generally decompose slowly and produce a poor or barren soil. The districts formed of these rocks are the least fertile in our state, except where overlying deposits of glacial drift and alluvium furnish a soil which is adapted to tillage and the support of vegetation.

Typical Localities of the Archaean

The most southern locality of Archaean rock in New York state is on New York island, between 7th and 8th avenues south of 155th street. This is a good exposure and is typical of the Archaean gneiss of southeastern New York. This gneiss is well shown throughout Westchester county along the shore of the Hudson, though at a few points Lower Silurian limestone and mica-schist occur. A little north of Peekskill may be seen the granite mountains of the Highlands, which traverse Orange and Putnam counties. These are chiefly massive, though on their flanks are some gneissoid rocks and in many of the valleys are Palaeozoic limestones and schists. Other localities are seen in Dover mountain and in Stissing mountain in Dutchess county. North of this southeastern area, the Archaean rocks are chiefly confined to the region known as the Adirondack wilderness.

PLATE VI.—To face page 140.

J. F. Kemp, photo.

FOLDS IN FORDHAM GNEISS, NORTH SIDE OF 138TH ST., EAST OF 7TH AVE., NEW YORK CITY. PRECAMBRIAN.

PLATE VII.—To face page 140.

H. Ries, photo.

HIGHLANDS OF THE HUDSON. PRECAMBRIAN. VIEW FROM PEEKSKILL.

Crow Nest. PLATE IX.—To face page 140. Storm King.

H. Ries, photo.

HIGHLANDS OF THE HUDSON. PRECAMBRIAN. CROW NEST AND STORM KING.

PLATE X.—To face page 140.

F. J. H. Merrill, photo.

VIEW OF THE HIGHLANDS OF THE HUDSON AND SUGAR LOAF MOUNTAIN, FROM FT. MONTGOMERY, ORANGE CO. PRECAMBRIAN.

PLATE XI.—To face page 140.

H. Ries. photo.

BREAKNECK MOUNTAIN. SEEN FROM THE SHORE OPPOSITE COLD SPRING, PUTNAM CO. PRECAMBRIAN GRANITE.

PLATE XII.—To face page 140.

Quaternary overlying Lower Silurian.

Precambrian granite.

H. Ries, photo.

FISHKILL MOUNTAIN, SEEN FROM CORNWALL, ORANGE CO. PRECAMBRIAN AND LOWER SILURIAN.

PLATE XIII.—To face page 140.

S. R. Stoddard, photo.

GORGE OF THE HUDSON RIVER, LUZERNE, WARREN CO., AND HADLEY, SARATOGA CO. PRECAMBRIAN GNEISS.

PLATE XIV.—To face page 140.

PRECAMBRIAN ROCKS, ADIRONDACK MOUNTAINS. AVALANCHE LAKE, ESSEX CO.

PLATE XV.—To face page 140.

S. R. Stoddard, photo.

PRECAMBRIAN ROCKS, NORTH END OF WILLSBORO TUNNEL, SHORE OF LAKE CHAMPLAIN, ESSEX CO.

PLATE XVI.—To face page 140.

J. N. Nevius, photo.

PRECAMBRIAN MARBLE, E. E. STEVENS' QUARRY, 3 MILES SOUTH OF CANTON, ST. LAWRENCE CO.

PLATE XVII.—To face page 140.

J. N. Nevius, photo.

EMPIRE MARBLE CO.'S QUARRY NEAR GOUVERNEUR, ST. LAWRENCE CO.
PRECAMBRIAN.

The principal group of mountains, which includes Mt Marcy, is of massive rocks known as norite and anorthosite. The prevailing rocks of the wilderness are, however, gneisses of different kinds. In these are many local intrusions of granite and other eruptives. Trap, serpentine and many other rocks of igneous origin are found in all parts of the district. The great route of travel through Lakes George and Champlain is bordered by mountains and cliffs, in which these rocks are seen in great variety.

In the Mohawk valley are small exposures of pre-Cambrian, at Littlefalls and near Spraker's. These are important localities and show the relations of the over-lying Palaeozoic rocks.

Proterozoic or Agnotozoic

Rocks of this age are not definitely known in New York. They are well represented in the Lake Superior region by those formations known as Huronian and the copper bearing deposits of the Keeweenaw peninsula. West of the Rocky mountains, they are developed extensively. All rocks between the Archaean and the Cambrian are included.

Palaeozoic

Upon the plutonic and metamorphic rocks of the Archaean in New York rest directly the Palaeozoic strata which are all fossil-bearing rocks. The Palaeozoic series includes all strata from the base of the Cambrian to the summit of the Carboniferous.

These stratified fossil-bearing rocks form the greater part of the state of New York.

At the beginning of the Palaeozoic, all life was marine, probably because the land surfaces were at first too small to materially influence the evolution of living forms. In the Cambrian, crustaceans prevailed, in the Lower Silurian the Cephalopods or cuttle fishes, in the Devonian the soft boned fishes were the dominant type, while in the Carboniferous, fishes and amphibians divided the honors of the sea and the land.

In like manner plant life, beginning with marine forms of low type, gradually developed to the large tree ferns, sigillaria, lycopods and equisetae of the coal measures.

CAMBRIAN[a]

Subdivisions or periods

Potsdam	Sandstone around the Adirondacks Limestone in Dutchess, Washington and Saratoga counties
Acadian	Limestone in Dutchess county
Georgian	Roofing slates of Washington county Quartzite in Dutchess county

The first and lowest Palaeozoic system known in New York is the Cambrian, so called from *Cambria*, the latin name of Wales, where rocks of this age abound and were first studied by the British geologist, Adam Sedgwick. Our knowledge of the Cambrian of New York is largely due to the labors of C. D. Walcott, William B. Dwight, and S. W. Ford.

The base of the Cambrian system in New York and New England rests directly upon the Archaean rocks and its limit can be recognized by this fact, as well as by its containing the earliest known fauna. But the termination of the uppermost division is not so apparent, as it grades, both in sediment and fauna, into formations of the Lower Silurian system, thus showing that there was no great physical change to influence the transition. North of the Adirondacks the delimitation is more clearly defined.

The strata of the Cambrian system are classified as follows:

Upper Cambrian, or Potsdam.

The type rock is the sandstone of the northern and eastern borders of the Adirondack mountains, and correlated with it are certain limestones on the south side of the Adirondacks, near Whitehall and Saratoga Springs, and in Dutchess county near Poughkeepsie. The characteristic fossils are the Dikelocephalus trilobites.

[a] The descriptions of the Georgian and Acadian groups are chiefly from the work of C. D. Walcott, Bulletin No. 81, U. S. Geological Survey.

Middle Cambrian, or Acadian.

The type rocks are the shales and slates of New Brunswick, Newfoundland and Braintree, Mass., and correlated with them are some limestones in Dutchess county. The characteristic fossils are the Paradoxides trilobites.

Lower Cambrian, or Georgian.

The type rocks are slates, limestones and the 'red sandrock' of western Vermont; and correlated with them the shales and interbedded limestones and roofing slates of Washington and Rensselaer counties. The characteristic fossils are the Olenellus trilobites.

Georgian

The lowest rock is a bedded quartzite, resting upon the Archaean. This is seen on the flank of Stissing mountain, and between Fishkill and Poughquag, in Dutchess county. From here its outcrops extend northeasterly through Massachusetts and Vermont, where it attains a great thickness.

At Stissing mountain it passes above into a limestone containing Lower Cambrian fossils. Above this lies a considerable thickness of arenaceous limestone, frequently passing into calcareous shale, and containing Middle Cambrian fossils.

Near Poughkeepsie an extensive limestone formation contains Upper Cambrian fossils.

Northward, in Washington county, the quartzite is represented by a great thickness of shales, slates, sandstones and limestones, well shown along a line between Greenwich and Salem, and the superjacent limestones of Dutchess county are entirely replaced in both Rensselaer and Washington counties by slates, shales and sandstones. Mingled fossils of Lower and Middle Cambrian are found at Berlin, Rensselaer county. These formations continue northeastward into Canada.

The great belt of *roofing slate* in western Vermont and Washington county, belongs to this (Georgian) group. The greatest development of this formation is at Georgia, Vt., from which place it extends southward into Washington county, where it

is quarried at Middle Granville and vicinity, and broadening out southward, extends nearly across the southern part of Rensselaer county.

Acadian

The Middle Cambrian, or Acadian, group is not so well developed in New York.

Marble and limestone of this age are found resting conformably upon the Lower Cambrian rocks about Stissing mountain, shown in the cut for the N. Y. & Mass. R. R. near Stissing, and extending into Massachusetts, where the development is greater. A portion of the Stockbridge limestone may belong to this group, though most of it is Lower Silurian.

Potsdam

The Upper Cambrian, or Potsdam, group is exposed over a larger area in New York than the two lower divisions and is typically represented by the Potsdam sandstone, which is seen in many places to rest directly upon the Archaean. It is a hard silicious sandstone and an excellent building material, often thinly bedded and usually reddish-brown in color, though sometimes gray or buff. On many of its layers, are waved surfaces, precisely resembling the ripple-marks seen on sandy bottoms over which waters are agitated by waves or currents. They were formed in the same way, by movements of the waters in which were deposited the sands which were finally hardened into the Potsdam sandstone. Similar markings are frequent on almost all sandstones. The edge of this formation can be traced nearly all around the region of the Adirondacks, except between Canajoharie and Carthage, and is especially well seen near Keeseville in Clinton county, where the deep chasm of the Ausable river is cut through it, showing 333 ft. of horizontal strata, at Chateaugay chasm, where the section exposes a thickness of 250 ft., and at Potsdam, St Lawrence county, from which place it received its name, and where, in the valley of the Raquette river a thickness of 70 ft. is shown.

PLATE XVIII.—To face page 144.

J. N. Nevius, photo.

POTSDAM SANDSTONE, QUARRY OF MERRITT & TAPPAN, 3 MILES SOUTH OF POTSDAM, ST. LAWRENCE CO.

PLATE XIX.—To face page 144.

J. N. Nevius, photo.

POTSDAM SANDSTONE RESTING UNCONFORMABLY UPON PRECAMBRIAN GNEISS. DODGE FARM, MACOMB, ST. LAWRENCE CO.

PLATE XX.—To face page 144.

N. H. Darton, photo.

POTSDAM SANDSTONE RESTING UNCONFORMABLY ON PRECAMBRIAN GNEISS. HUDSON RIVER NEAR JESSUPS LANDING, SARATOGA CO.

PLATE XXI.—To face page 144.

S. R. Stoddard, photo.

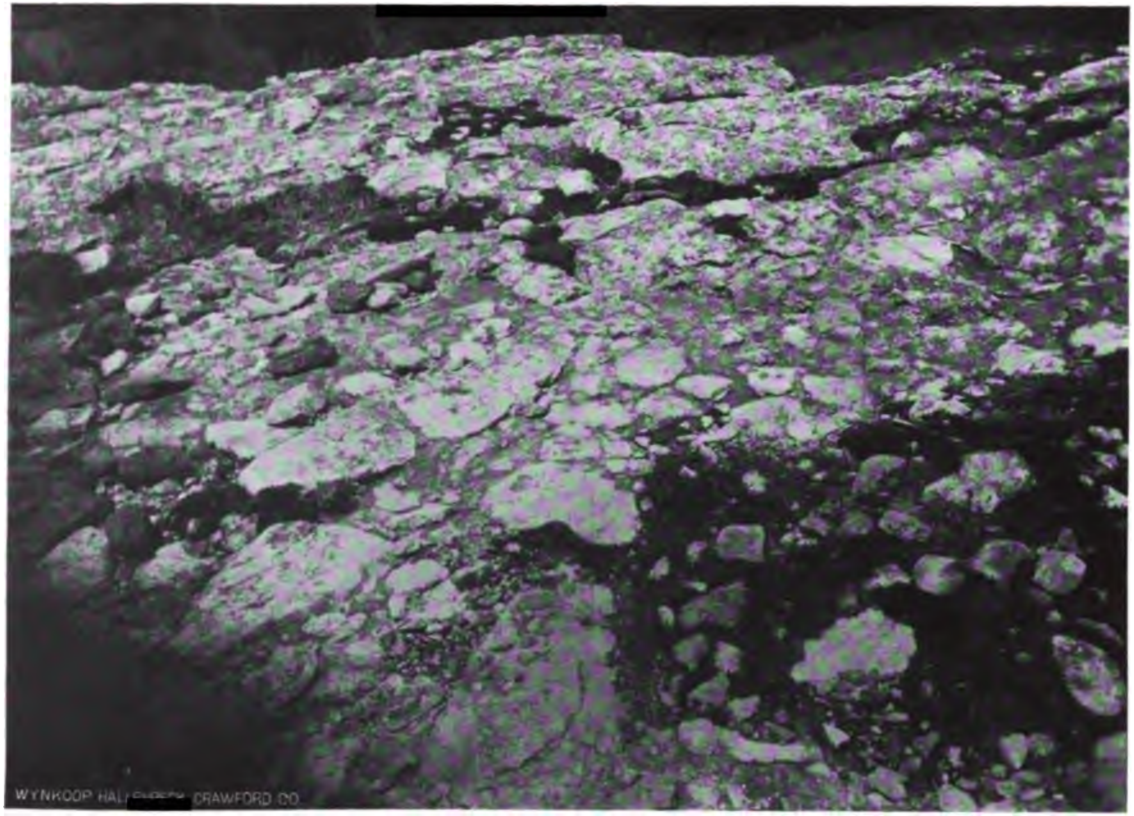
HELL GATE, AUSABLE CHASM, CLINTON CO. POTSDAM SANDSTONE.

PLATE XXII.—To face page 144.

S. R. Stoddard, photo.

POTSDAM SANDSTONE, GRAND FLUME, AUSABLE CHASM, CLINTON CO.

PLATE XXIII.—To face page 144.



N. H. Darton, photo.

GLACIATED SURFACE OF POTSDAM CONGLOMERATE, MOSHERVILLE, SARATOGA CO.

PLATE XXIV.—To face page 144.

N. H. Darton, photo.

POTSDAM CONGLOMERATE ON PRECAMBIAN CRYSTALLINE ROCKS, MOSHERVILLE, SARATOGA CO.

In the northern part of Lewis county the Potsdam sandstone, in a few small exposures, rests unconformably upon the Archaean terrane, and passes above into the Calciferous formation. It extends almost continuously through Jefferson, St Lawrence, Franklin and Clinton counties, and appears southward in the Champlain valley in irregular outcrops.

The Potsdam, though not seen distinctly in the Mohawk valley (where its place between the Archaean and the Calciferous sand rock appears to be vacant) is a thick mass in Pennsylvania, and is known northeastward and northwestward over a great area.

The base of the Potsdam at a few places in New York is a coarse conglomerate which gradually passes upward into the typical sandstone.

Near Whitehall, Saratoga and Poughkeepsie, the Potsdam horizon is represented by a limestone and at the two former localities it passes upward into the Calciferous formation without marked change except in fauna.

The characteristics of the Cambrian strata lead to the conclusion that the sediments were accumulated in shallow seas near the shore of a slowly sinking land. As the water slowly encroached upon the land in late Middle or early Upper Cambrian time, deeper water gradually covered the earlier longshore deposits, and finer sediments were deposited upon them. Toward the close of Cambrian time (Potsdam) only the higher parts of the continent were above the sea. At this time the Potsdam sandstone was deposited along the shores, while in the deeper water the conditions were becoming favorable for the formation of the great beds of Silurian limestone. The conglomerate at the base of the Potsdam, grading upwards into the finer sediments of the sandstone, indicates the deepening of the water along the shore line of the Cambrian ocean.

At their greatest development in Washington county, the Cambrian formations have a total thickness of 10,000 or 12,000 feet.

Life of the Cambrian

So far as we know, the life of the Cambrian was wholly marine. No vertebrates are known to have existed. The Brachiopods were small. The Lamellibranchs, so far as known, were also very small. There were representatives of the groups of Pteropods and Gastropods. Cephalopods appeared in the Upper Cambrian. There were also sponges, and corals. The trilobites, however, were the only forms which had attained large size or high development. Besides these were some other articulates, the Ostracoids and Phyllopods, and probably some worms. The plants were sea weeds.

LOWER SILURIAN OR ORDOVICIAN

This system is a subdivision of the original Silurian system which received its name from that of the *Silures*, an ancient race inhabiting the eastern part of Wales, where Sir Roderick Murchison studied these rocks in detail. The second name was derived by the British geologist Lapworth from that of the *Ordovices*, also an ancient British tribe.

In New York this system is well developed and includes the following subdivisions:

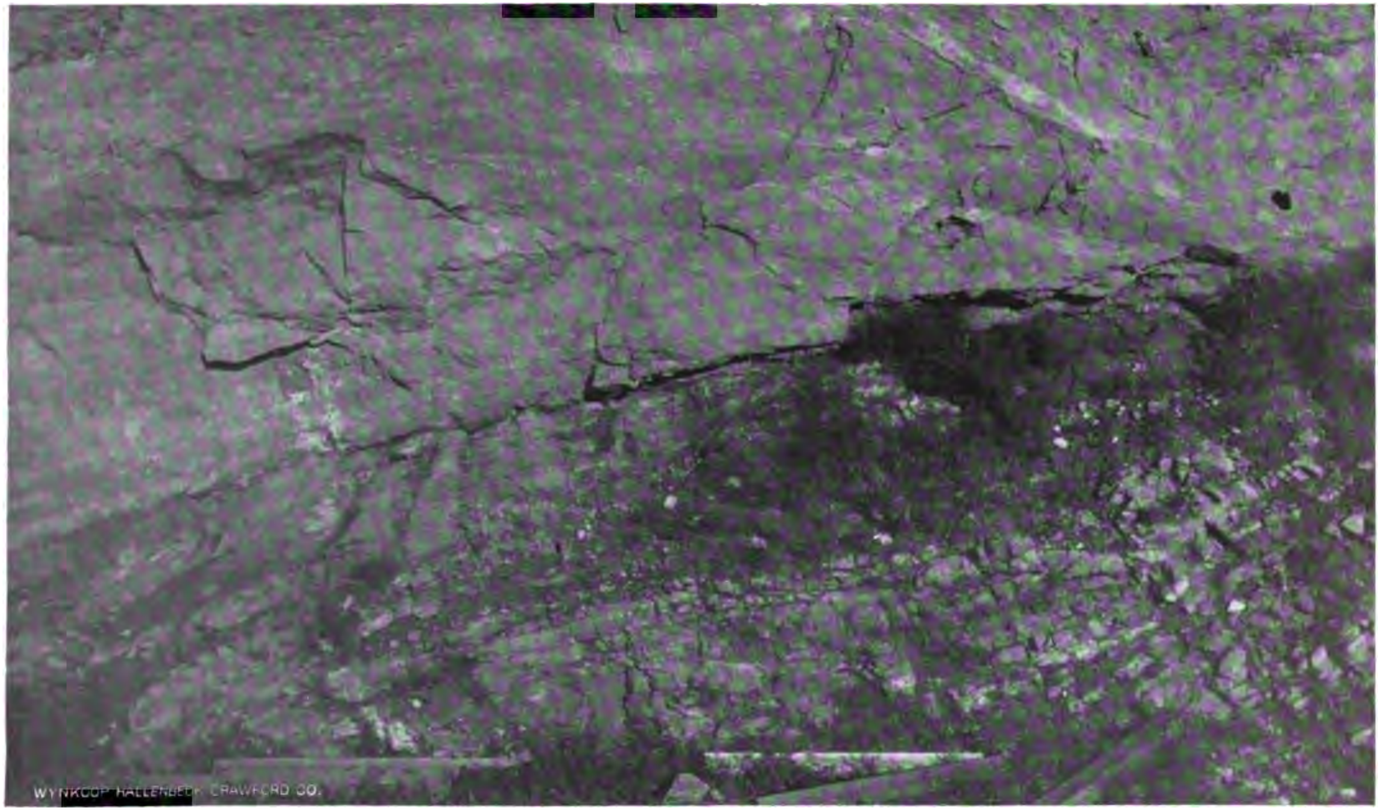
System	Group	Stage
Lower Silurian	Hudson river	Hudson river shale and sandstone
		Utica slate
	Trenton	Trenton
		Black river
		Birdseye
		Chazy
	Calciferous	

Calciferous Group

Overlying the Upper Cambrian or Potsdam sandstone at many points is another, which contains a considerable proportion of lime mingled with it, and from this fact has received the name of the Calciferous sandrock.

It may be described as a silicious or gritty limestone, generally of a brownish color, lying in straight, thin layers, and attaining

PLATE XXV.—To face page 146.



N. H. Darton, photo.

CALCIFEROUS SANDROCK RESTING ON PRECAMBRIAN CRYSTALLINE SCHISTS, WEST SHORE R. R. CUTTING, 1 MILE WEST OF DOWNING STATION, MONTGOMERY CO.

PLATE XXVI.—To face page 146.

N. H. Darton, photo.

CALCIFEROUS SANDROCK, EAST CANADA CREEK, HERKIMER CO., 1 MILE ABOVE ITS MOUTH.

PLATE XXVII.—To face page 146.

N. H. Darton, photo.

CALCIFEROUS SANDROCK. EAST CANADA CREEK, HERKIMER CO., TWO MILES ABOVE ITS MOUTH.

PLATE XXVIII.—To face page 146.

H. Ries, photo.

VIEW OF INWOOD, MANHATTAN ISLAND. (PLAIN OF CALCIFEROUS-TRENTON LIMESTONE. HILLS RIGHT AND LEFT OF HUDSON RIVER SCHIST. PALISADES (TRIASSIC) IN THE BACKGROUND.

PLATE XXIX.—To face page 146.

H. Ries, photo.

MARBLE QUARRY, SING SING, WESTCHESTER CO. METAMORPHOSED CALCIFEROUS-TRENTON LIMESTONE.

Lake Champlain: it is a fine grained, gray, brittle, limestone, 30 feet in its greatest thickness: and the most conspicuous of its fossils is one of which the nature is somewhat obscure, but which was regarded as the stem of some marine plant.

Standing in an upright position, perpendicular to the strata the ends of the stems are seen on the surface of the layers, to which they give a peculiar dotted appearance, from which the rock has derived its name, and by which, as well as by its characteristic color and fracture, it is easily recognized. It is a valuable rock for economical uses, as it is a good building stone, and dresses well under the chisel; it is quarried to a considerable extent at various points in the Mohawk valley.

Black River Limestone

To the Birdseye limestone succeeds a thin mass, amounting in all to only 10 or 12 feet, but classed as a distinct rock from having a somewhat peculiar mineral character and containing a peculiar set of fossils. It is a dark, thick-bedded, compact, hard limestone, fine grained and taking a high polish, and is worked as a black marble at Glens Falls on the Hudson river, and at Isle La Motte on Lake Champlain. It is also well seen at Watertown, Jefferson county, in the banks of the Black river from which locality it has been named.

In the last place it is lumpy and irregular in texture, and not fit for good masonry or marble; and is known among quarrymen as ' the seven foot tier.' In the Mohawk valley it seems to have been deposited in only a few places, the Birdseye being generally covered directly by the Trenton.

Trenton Limestone

Above the Black river limestone (or where this is absent, lying upon the Birdseye), is one of the most interesting repositories of organic remains in the state; a thick group of limestone strata, usually black and fine grained with seams of slate toward the lower part, but gray and crystalline near the top.

PLATE XXX.—To face page 148.

N. H. Darton, photo.

GLENS FALLS ON THE HUDSON RIVER, SARATOGA AND WARREN COUNTIES. TRENTON LIMESTONE.

PLATE XXXI.—To face page 148.

N. H. Darton, photo.

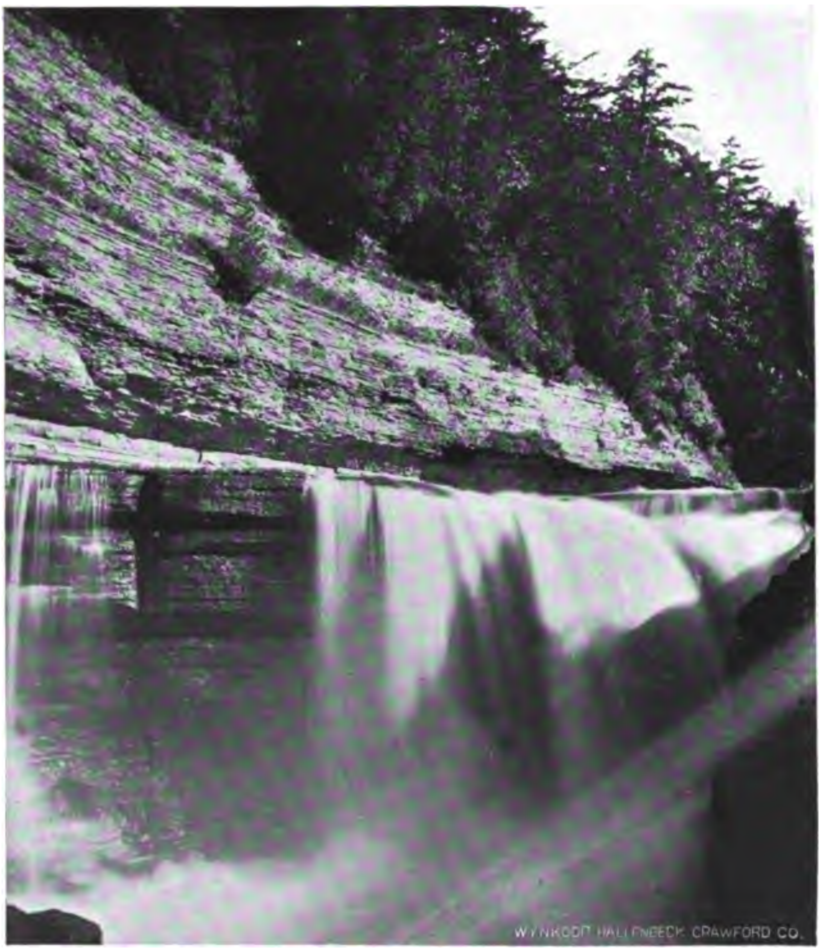
UPPER GORGE, TRENTON FALLS, ONEIDA CO. TRENTON LIMESTONE.

PLATE XXXII.—To face page 148.

N. H. Darton, photo

PRINCIPAL CASCADE, TRENTON FALLS, ONEIDA CO. TRENTON LIMESTONE.

PLATE XXXIII.—To face page 148.



N. H. Darton, photo.

TRENTON LIMESTONE, SPENCER FALL, TRENTON FALLS, ONEIDA CO.

PLATE XXXIV.—To face page 148.

N. H. Darton. photo.

UTICA SHALE, TRENTON LIMESTONE AND CALCIFEROUS SANDROCK, CANAJOHARIE, MONTGOMERY CO.

It attains an entire thickness of more than 300 feet, and, succeeding the lower rocks as already described, its edges surround the great Adirondack region in an almost unbroken circuit. Seen at Glens Falls on the Hudson, along the Mohawk at Fort Plain and elsewhere, on the west shore of Lake Champlain, and at many points on the shores of the St Lawrence, it also outcrops along the valley of the Black river and is crossed by West Canada creek at Trenton Falls, from which place it takes its name.

In many places it furnishes building stone of excellent quality.

Hudson River Group

This formation, which is next in upward succession, is an enormous deposit of sandstone, slate and shale. The lower part of the Hudson river group is a fissile black slate about 75 feet thick, known as the Utica slate.

The higher strata, to which the name of the Hudson river group is more usually restricted, are gray slaty masses, with coarse sandstones, especially toward the top, and in some places near the summit of the group, a coarse sparry limestone.

In the eastern part of the state these rocks are 3,500 feet thick, as shown by a boring near Altamont in Albany county. They are well seen in the north of Oswego county, near Pulaski, the south of Lewis county and the middle of Oneida county; also through the Mohawk valley, and from Glens Falls southward along the Hudson river, from which these strata take their name. West of Schenectady they are generally level and undisturbed; but near the Hudson river these strata are upheaved, broken, folded and faulted in every conceivable manner, as may well be seen in many places near Cohoes and Albany and along the Hudson river railroad. In much of this disturbed region the rock has been changed in texture by the forces to which it has been subjected and fossils are very rare.

That part of New York lying east of the Hudson, and along the western border of New England is formed of an enormous mass of upheaved and contorted strata of slate, schist sandstone and limestone, which were at one time supposed to be older than

the Potsdam sandstone, and were called Taconic. This range of rocks contains very few fossils or none in most localities, and geologists have been obliged to study it without the aid which fossils would have given in explaining the relation and true position of its confused and contorted strata. The general conclusion has been that this series of strata is not a separate and distinct one, but merely the eastward extension of the rocks older than the Medina and Clinton groups, changed in character or 'metamorphosed' by the effect of heat and pressure. The work of Walcott and others has proved that most of the schistose rocks are of Hudson river age, though a portion of them contain Lower and Middle Cambrian fossils and are therefore distinct.

In Westchester and New York counties, rocks of Hudson river age cover large areas. They are, however, metamorphosed into mica schist and contain no fossils.

Life of the Lower Silurian

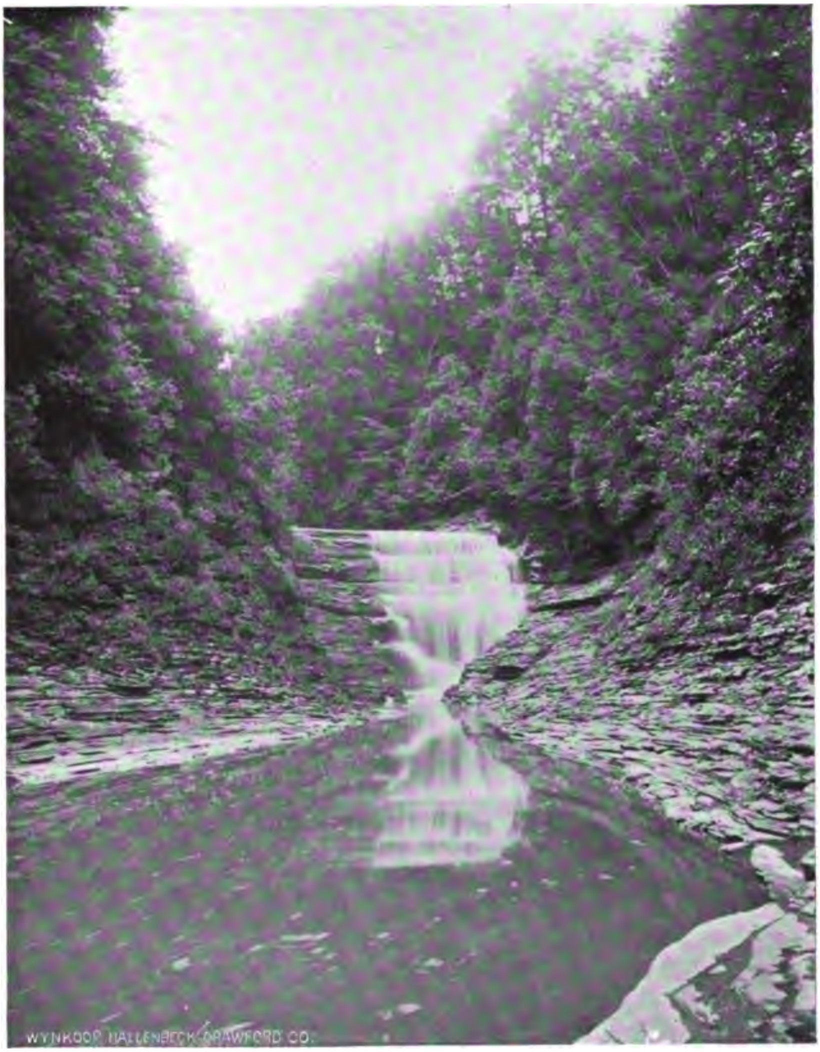
The animal life of this system was also marine and chiefly represented by sponges, corals, brachiopods, mollusks and crustaceans. Cephalopods were the dominant forms and were of great size. Fishes have recently been announced by C. D. Walcott. No land animals are known to have existed except some insects reported from Europe. Vegetable life was represented by sea weeds, though a land plant has been found in Great Britain.

UPPER SILURIAN SYSTEM

The Upper Silurian system, which is the upper division of the original Silurian system, consists in New York state of the following divisions:

System	Group	
	Lower Helderberg	
	Onondaga Salt Group	Waterlime Salina
Upper Silurian	Niagara	
	Clinton	
	Medina	
	Oneida	

PLATE XXXV.—To face page 150.



N. H. Darton, photo.

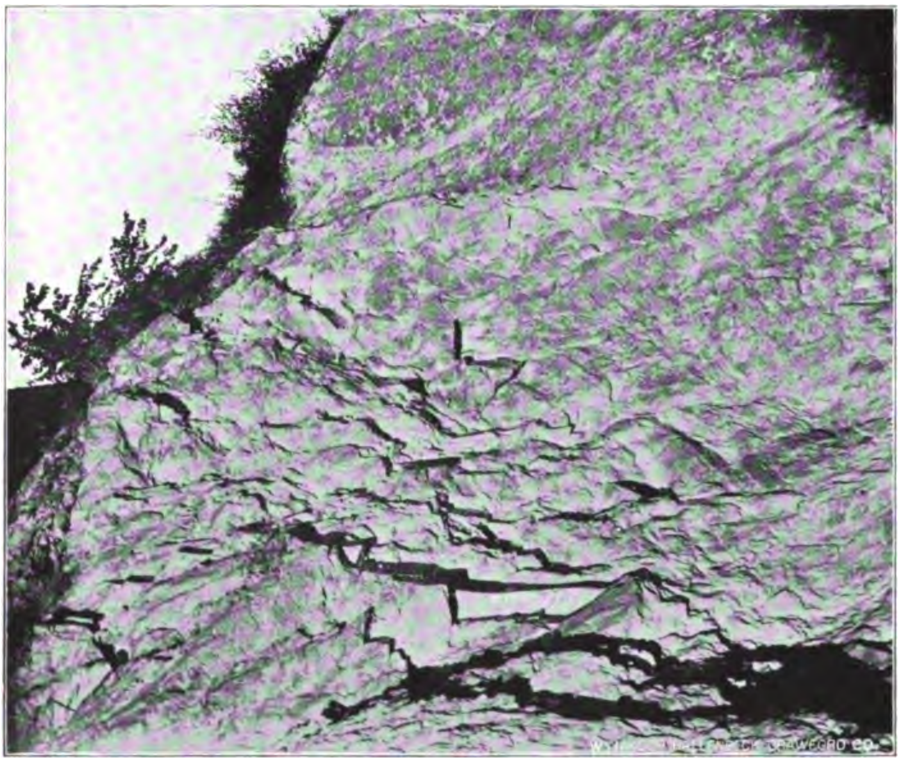
GORGE IN THE UTICA SHALE SOUTH OF CANAJOHARIE, MONTGOMERY CO.

PLATE XXXVI.—To face page 150.

H. Ries, photo.

FOLD IN SANDSTONES OF THE HUDSON RIVER GROUP, CATSKILL CREEK, GREENE CO.

PLATE XXXVII.—To face page 150.



J. N. Nevius, photo.

HUDSON RIVER SHALE IN RAILROAD CUTTING. KENWOOD. ALBANY CO. DIP VERTICAL.

PLATE XXXVIII.—To face page 150.

J. F. Kemp, photo.

CRUMPLED HUDSON RIVER SCHIST, WITH PEGMATITE VEINS, OPPOSITE 130TH ST., ON WEST SIDE OF ST. NICHOLAS AVE., NEW YORK CITY.

PLATE XXXIX.—To face page 150.

H. Ries, photo.

METAMORPHOSED HUDSON RIVER MICA SCHIST OVERLYING SEMICRYSTALLINE CALCIFEROUS-TRENTON LIMESTONE.
VERPLANCK'S POINT, WESTCHESTER CO.

Generally speaking, the lowest of these groups lies conformably upon the strata of the Hudson river group,—the uppermost of the Lower Silurian,—though in eastern Albany county the Hudson river shales are much disturbed.

In regard to this relation it has been said by Dana[a]: 'Cases of intervening erosion may be found, for every period loses by erosion a large part of its deposition in the supply of material for the beds of the following period.'

Oneida Conglomerate

The Hudson river group is covered in many places by a bed of conglomerate consisting chiefly of coarse sand and rounded pebbles of quartz, cemented together into a firm mass. Being well developed in Oneida county south of Utica, it has received its name from that of the county.

It is the base of the Lower Silurian system. In central New York it is but a few feet in thickness, and indeed seems to be entirely wanting in many places; but in the lower Hudson valley it swells to a thickness of several hundred feet and southwest of Rondout forms the Shawangunk mountain from which it receives the name of Shawangunk grit. From this place its upheaved edges may be traced in the range of hills southeast of the Delaware and Hudson canal and parallel to it, and the same rock forms most of the mountain range of the Kittatinny or Blue Ridge, along which the Delaware flows from Port Jervis, where it leaves New York, to the famous Delaware Water Gap where it cuts through the barrier. From this point, its edge ranges southward to Virginia. No fossils have yet been discovered in it: indeed the rolled and worn condition of its materials would indicate that it was formed under agitated waters, which did not allow the growth or preservation of organic forms.

The well known summer resort of Lake Mohonk is on the Shawangunk grit.

The 'Rensselaer plateau,' in Rensselaer county, is an extensive outcrop of greenish conglomerate, resting conformably

a Man. Geol. pp. xxx

upon the Hudson river schists. This is probably equivalent to the Oneida conglomerate, or possibly the base of the Medina group.

The source from which such enormous quantities of rolled pebbles of quartz could have been derived and the mode by which they could have been spread so widely over a sea bottom is a very obscure question in geology. Several other such formations of conglomerate are known, two of which occur at the lower and middle parts of the Carboniferous system.

Medina Sandstone

The next succeeding group is that named from a village in Orleans county where it is well exposed.

It is a huge mass of sandy and shaly rock, of very variable hardness from soft marl to hard sandstone, and varying in color from deep red to olive and light gray. It is not known in the far west, seeming to thin out and disappear before reaching Wisconsin, but is well seen on the Niagara river, where it forms most of the precipice near Lewiston. At this point the lower part is a soft red shale, with harder and lighter colored layers above, to one heavy bed of which the cables of the Lewiston suspension bridge are fastened. This sandstone may also be seen in the lower part of the river cliffs, extending as far as the upper Suspension Bridge. The same rock is quarried near the lower part of Lockport for building and flagstone, and it forms the lower falls of the Genesee at Rochester, at the top of which the hard uppermost layer, called the 'Gray band,' is very conspicuous from its light color. Further east, the same rock forms the falls of the Oswego river at Fulton; but in the Mohawk valley it thins out, and disappears. In southeastern New York, however, near Rondout, it re-appears and is very thick at the Delaware water gap in New Jersey and Pennsylvania, reaching, in the latter state, the thickness of 1,000 feet; and it may be recognized as far south as Alabama.

PLATE XL.—To face page 152.

N. H. Darton, photo.

EASTERN FACE OF SHAWANGUNK MOUNTAIN, 2 MILES SOUTH OF LAKE MOHONK, ULSTER CO. ONEIDA CONGLOMERATE RESTING ON HUDSON RIVER SHALE.

PLATE XLI.—To face page 152.

N. H. Darton, photo.

CLIFFS OF SHAWANGUNK GRIT ON THE WEST SHORE OF LAKE MOHONK, ULSTER CO.

PLATE XLII.—To face page 152.

N. H. Darton, photo.

AWOSTING FALLS OVER SHAWANGUNK GRIT, PETERKILL, NEAR LAKE MINNEWASKA, ULSTER CO. ONEIDA CONGLOMERATE.

PLATE XLIII.—To face page 152.

Medina shales and sandstone.

I. P. Bishop, photo

NIAGARA GORGE NEAR LEWISTON. MEDINA GROUP.

PLATE XLIV.—To face page 152.

Clinton limestone.

Clinton shale.

Medina grey sandstone.

Medina red shales and sandstones.

I. P. Bishop, photo.

NIAGARA RIVER GORGE, SOUTH OF LEWISTON, NIAGARA CO.

PLATE XLV.—To face page 152.

J. N. Nevius, photo.

BEACH MARKINGS ON MEDINA SANDSTONE.

SEAWEED, ARTHROPHYCUS HARLANI, ON MEDINA SANDSTONE.

PLATE XLVI.—To face page 152.

J. N. Nevius, photo.

BEACH MARKINGS ON MEDINA SANDSTONE, LOCKPORT, NIAGARA CO.
ORIGINAL SLAB 53 INCHES BY 32 INCHES.

PLATE XLVII.—To face page 152.

I. P. Bishop, photo.

FALLS OVER MEDINA GREY SANDSTONE, NEAR LOCKPORT, NIAGARA CO.

PLATE XLVIII.—To face page 152.

I. P. Bishop, photo.

MEDINA GREY SANDSTONE, NEAR LOCKPORT, NIAGARA CO. QUARRY OF R. KEENEY.

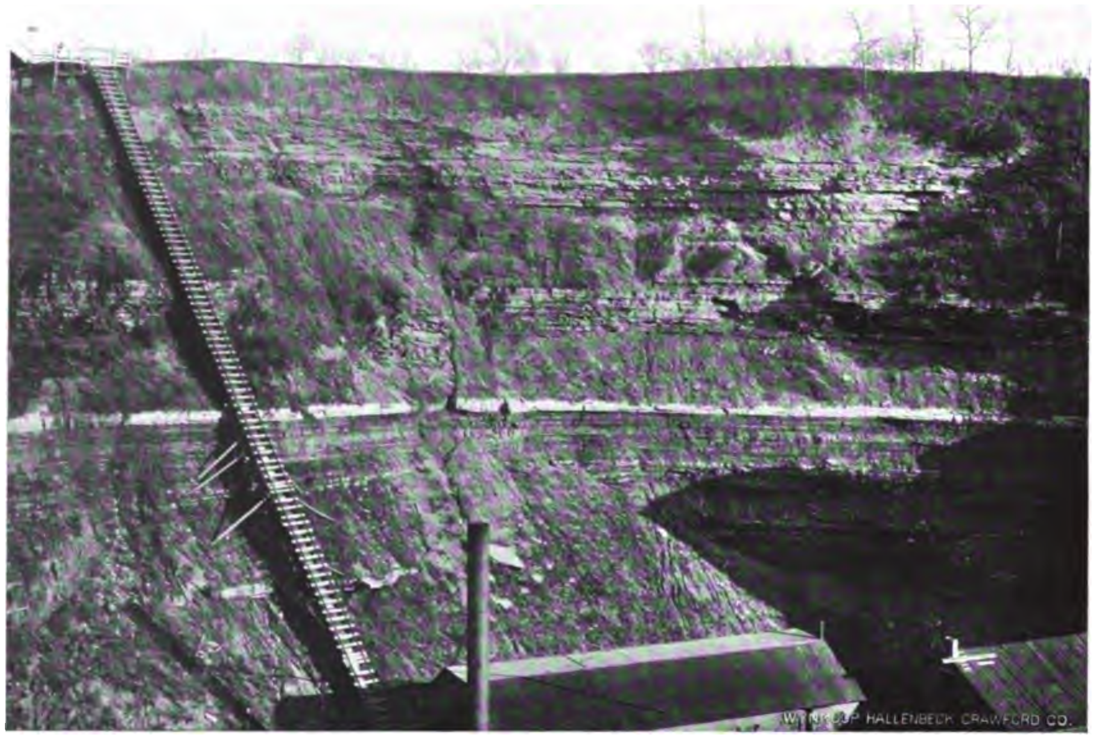
PLATE XLIX.—To face page 152.

Clinton lower limestone.
Clinton lower shale.
Grey Medina sandstone.
Red Medina shales and sandstones.

Webster & Albee, photo.

LOWER FALLS OF THE GENESEE RIVER, OVER THE GREY MEDINA SANDSTONE. MONROE CO. MEDINA AND CLINTON GROUPS.

PLATE L.—To face page 152.



Webster & Albee, photo.

GORGE OF THE GENESEE RIVER, MONROE CO., BELOW THE LOWER FALLS. MEDINA, CLINTON AND NIAGARA GROUPS.

PLATE LI.—To face page 152.

Webster & Albee, photo.

GORGE OF THE GENESEE RIVER, MONROE CO., BELOW THE LOWER FALLS. MEDINA AND CLINTON GROUPS.

Clinton Group

Above the Medina sandstone lies a series of sandstones, limestones and shales, which receives its name from one of the localities where it is well seen, the vicinity of Clinton, Oneida county. This group of strata is hardly distinguishable east of Fulton county, appearing to thin out in the eastern part of the state, where it is all sandstone and greenish shale. In the western part of the state, however, it contains two distinct layers of limestone and two of greenish shale, which can be well examined above the lower falls of the Genesee river near Rochester. Two thin strata of iron ore are found in this group, and are extensively mined in the vicinity of Clinton; the ore is of a peculiar granular appearance like an aggregate of small shot, and contains many fossils of small size.

On the Niagara river, the upper limestone of this group is about 20 feet thick, and a very solid, massive rock. At the falls, this layer is near the level of the water below the cataract.

This group of rocks extends westward through Canada, but does not appear beyond Wisconsin as a distinct mass. It re-appears in Pennsylvania in enormously increased thickness, amounting to nearly 2,000 feet, and extends southward along the Appalachian chain even to eastern Tennessee. It seems everywhere to contain beds of iron ore of the same character as those in New York.

Niagara Group

This group consists in the region from Wayne county westward of two distinct members, a shale and limestone, which, are recognized as the products of one period, during which, there was an important change in the materials deposited and a lesser one in the animal life. The shale is a very uniform deposit throughout the whole extent of the fourth district; while the limestone, from a thin, dark colored, concretionary mass at the east becomes an extensive and conspicuous rock, constantly increasing in thickness in a westerly direction, even far beyond the limits of the state.

The cataract of Niagara is produced by the passage of the river over this limestone and shale; and from being a well known and extremely interesting locality, as well as exhibiting the greatest natural development of these rocks within the limits of the state, this name has been adopted for its designation.

Standing on the upper suspension bridge at Niagara Falls, one sees in the precipice, above the Clinton limestone, a sloping bank of soft gray shale about 80 feet thick, above which succeeds a thick series of layers of limestone forming the brink of the rocky wall: these are the Niagara shale and the Niagara limestone. The great cataract pours over their edges; and its vertical descent is owing to the fact that the soft shale below wears away more rapidly than the hard limestone which forms the top of the fall, thus maintaining a recess behind the descending sheet of water. These rocks are perfectly exhibited in the gorge of the Niagara river, especially along the Niagara Falls and Lewiston railroad.

The limestone at Niagara is about 160 feet thick (of which only the lower part is seen at the falls); at Rochester it is about 70 feet thick. The shale decomposes rapidly where exposed to the air, until it resembles a deposit of gray clay. It contains thin layers of limestone in many places, the surfaces of which are often covered with beautiful small corals of several species, and the shale itself contains them in great numbers. The 'deep cut' of the canal above Lockport is through the Niagara limestone, some layers of which there form a massive and beautiful building stone. The same limestone and shale form the upper falls of the Genesee at Rochester.

Salina Group, or Onondaga Salt Group

The next series of strata in upward succession is a group of shales and thin limestones, the whole of which in central and western New York attains a thickness of nearly 1,000 feet. Its lower part in central New York is composed for several hundred feet of a soft red shale or hardened clay, especially conspicuous along the Erie canal in Madison county. Its upper

PLATE LII.—To face page 154.

Niagara shale.

Clinton limestone.

I. P. Bishop, photo.

NIAGARA RIVER GORGE, BELOW DEVIL'S HOLE, NIAGARA CO. NEW YORK CENTRAL RAILROAD CUT.

PLATE LIII.—To face page 154.

Niagara shale.

Clinton limestone.

Clinton shale.

Medina grey sandstone.

I. P. Bishop, photo.

NIAGARA RIVER GORGE, SOUTH OF LEWISTON, NIAGARA CO. NEW YORK CENTRAL R. R. CUT.

PLATE LIV.—To face page 154.

I. P. Bishop, photo.

WALL OF THE NIAGARA RIVER GORGE, AMERICAN SIDE. VIEW FROM FOSTER'S FLATS, 1½ MILES NORTH OF SUSPENSION BRIDGE.

Niagara limestone.

Niagara shale.

Clinton limestone.

Clinton shale.

Upper grey Medina.

Medina red shales and sandstones.

I. P. Bishop, photo.

NIAGARA GORGE BELOW THE SUSPENSION BRIDGE, NIAGARA CO. VIEW FROM THE CANADIAN SIDE.

I. P. Bishop, photo.

NIAGARA RIVER GORGE, FROM THE SUSPENSION BRIDGE, LOOKING NORTH. MEDINA, CLINTON AND NIAGARA GROUPS.

PLATE LVII.—To face page 154.

I. P. Bishop, photo.

OUTLET OF THE WHIRLPOOL, NIAGARA RIVER, NIAGARA CO. VIEW NORTHWARD FROM THE CANADIAN SHORE.

Webster & Albee, photo.

UPPER FALLS OF THE GENESEE RIVER, ROCHESTER, MONROE CO. NIAGARA GROUP.

PLATE LIX.—To face page 154.

Webster & Albee, photo.

GORGE OF THE GENESEE RIVER. BELOW THE UPPER FALLS, ROCHESTER, MONROE CO. NIAGARA GROUP.

PLATE LX.—To face page 154.

I. P. Bishop, photo.

NIAGARA RIVER, NIAGARA CO. VIEW FROM BLUFF NEAR LEWISTON, LOOKING NORTH.

Salina shales.

Niagara limestone.

Clinton shales.

N. H. Darton, photo.

UPPER SILURIAN ROCKS IN ROAD CUT NEAR HOWE'S CAVE, SCHOHARIE CO.

PLATE LXII.—To face page 154.

N. H. Darton, photo.

CLINTON AND SALINA GROUPS IN WEST BANK OF RONDOUT CREEK, HIGH FALLS, ULSTER CO., N. Y.

PLATE LXIII.—To face page 154.

N. H. Darton, photo.

ARCH IN SALINA AND CLINTON BEDS AT HIGH FALLS, ULSTER CO.

portion is generally a dark gray slaty rock, with layers of impure limestone, well seen along the Auburn and Syracuse railroad. The important salt springs of Syracuse being derived from these rocks, they received originally the name of Onondaga salt group.

In the days of the original Natural History Survey, the salt was not found in solid masses, though the gray part of the rock in some places showed impressions of the peculiar 'hopper shaped' crystals of halite or rock salt, proving that it once existed there in small quantities. It is now known to be diffused in beds and lenses through large extents of these strata, through which in places the surface water percolates and bears the salt in solution to the deep basin at Salina. This was found, by boring, to be several hundred feet in depth, filled with gravel and sand, in which the salt water seemed to lie as in a reservoir, and from which it is raised by the pumps for the supply of the evaporating works. The Onondaga lake, which is a comparatively shallow body of fresh water, lies over this deep mass of gravel, but has a water tight bottom of marl which keeps its fresh waters separate from the salt waters below.

During the past 18 years a large industry has been developed from the boring of salt wells in New York state at points distant from Syracuse, at Warsaw and in the Genesee valley. These wells show that rock salt in beds and lenticular masses varying in thickness from a few inches to 150 feet is abundantly intercalated between the layers of shale and limestone of the Salina group. This salt being easily soluble in water does not appear at the surface of the ground nor within reach of surface waters.

The upper drab or gray shales of this group contain great quantities of gypsum, which is quarried extensively from Madison county westward. The rock over the masses of gypsum often seems arched, as if this mineral, in forming, through some chemical change, had exerted an upward pressure, lifting the overlying masses.

The whole group is remarkably destitute of organic remains; not a single fossil having been found in the lower part or red shale, and but a small number in the upper portion at a few localities.

The Onondaga-salt group is hardly seen in New York east of Herkimer county. The succeeding formation, however, which is grouped with the Salina is fairly persistent.

Waterlime

Overlying the salt-bearing rocks and forming with them the Onondaga group is the Waterlime, a succession of dark-colored, fine-grained and straight-bedded layers of limestone, attaining in Madison county a thickness of over 100 feet. It lies immediately over the gray and drab limestones of the upper part of the salt group, and is not divided from them by any very distinct or sudden change in the appearance of the strata. The name is given from the waterlime or hydraulic cement which is extensively manufactured from two of the layers toward their upper part: these are generally of a drab color, and separated from each other by a thin mass of blue limestone. They are quarried, burnt and ground on a very large scale near Manlius in Onondaga county, and the hydraulic cement of Rosendale and Rondout is made from the same beds. That manufactured at Williamsville, Erie county, and at Buffalo, is from the upper limestones of the Salina group below; and in Niagara and Orleans counties, a similar cement is made from some layers of the Niagara group.

HELDERBERG ROCKS

Above the formations already described succeeds a thick series of strata, chiefly limestone, separated by sandstone and grit rocks, first described under the general name of the Helderberg rocks, as they formed the great escarpment of the Helderberg mountains in Albany county. From this place their edges may be followed southward in the hills lying west of the Hudson river, past the base of the Catskill mountains, and through Ulster county as far as Kingston and Rondout; whence their outcrops bend southwestward and extend along the hills west of the valley of the Delaware and Hudson canal, passing out of the state near the northwest corner of New Jersey. They run still farther southwestward, are seen above the Delaware Water Gap, and their

I. P. Bishop, photo.

MINE OR QUARRY OF THE CUMMINGS CEMENT CO., AKRON, ERIE CO.

N. B.—The term "bull-head" is used by the quarrymen to denote the impure limestone which overlies the cement rock and is unfit for use.

PLATE LXV.—To face page 156.

H. Ries, photo.

OLD MINE OF THE NEWARK CEMENT CO., RONDOUT, ULSTER CO. WATERLIME GROUP.

PLATE LXVI.—To face page 156.

N. H. Darton, photo.

HIGH FALLS OF RONDOUT CREEK OVER CEMENT BEDS OF THE WATERLIME GROUP, ULSTER CO.

lower strata are traceable in the Appalachians as far as Tennessee, though their upper limestones do not extend beyond the Susquehanna. In following them westward from Albany county, we find the lower limestones and sandstones thin out rapidly, not extending beyond the Niagara in any considerable thickness, while the upper limestones are found spreading into the far west.

This series of rocks which may be considered collectively in its effect on topography, belongs partly to the Upper Silurian system and partly to the Devonian and may be divided into two parts; the Lower Helderberg limestones which are of Upper Silurian age, and the Oriskany sandstone and Upper Helderberg limestones which are included in the Devonian.

Lower Helderberg Group

The subdivisions of this group are as follows:

	Thickness
Scutella limestone Upper Pentamerus	15 ft. in Albany county
Delthyris, or Catskill shaly limestone	100 ft.
Lower Pentamerus limestone	65 ft. in Albany county
Tentaculite limestone .	30 ft. "

The Scutella limestone, named from a fossil crinoid which it contains, is the uppermost member of the group where it occurs, but it has not been found associated with the Upper Pentamerus.

The Lower Pentamerus limestone is coarse-grained, thick-bedded and often a concretionary limestone; while the Catskill limestone is in thin layers, with much shaly or slaty matter interstratified with it.

The Lower Helderberg group has its greatest development in Albany and Schoharie counties; the subdivisions above given may be differentiated in Greene, Albany and Schoharie counties, but west of the last county they are not distinct and the group itself is indistinguishable from the Salina formation, at the surface, west of Seneca lake. In the Livonia salt shaft, however, about 35 feet of limestone was found containing Tentaculite fos-

sils. It may, with the waterlime, be traced through Pennsylvania and Virginia, but is very thin and not found everywhere, having been deposited locally in areas of no great extent.

Life of the Upper Silurian

There is no radical difference between the general character of the fossil remains of this system, and those of the Lower Silurian, but of several thousand species found in the Upper Silurian, only a few occur also in the Lower Silurian, and the animal forms are nearly all marine. Sea weeds were very abundant and a few land plants, similar to equisetae, occur.

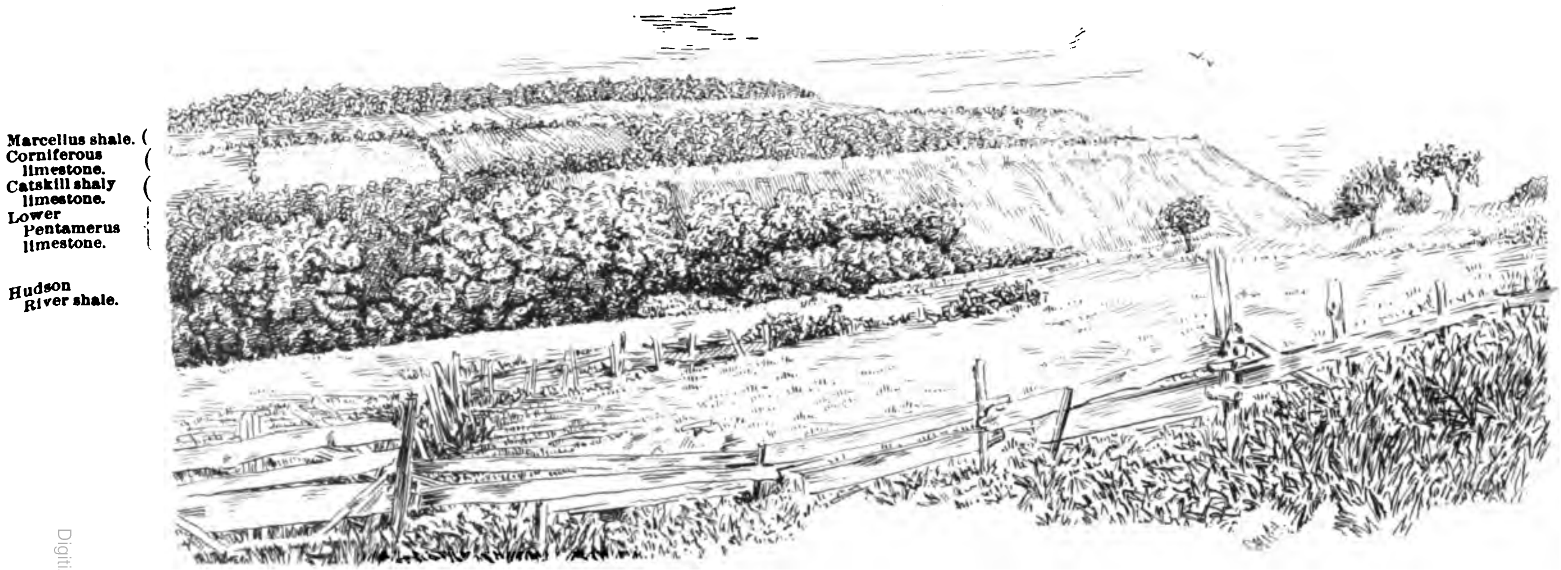
DEVONIAN SYSTEM

This system takes its name from Devonshire in England where its rocks were studied by Sir Roderick Murchison.

The Devonian was the age of fishes, since fishes were the prevailing type. America has probably the most complete series known of the Devonian rocks but they have a comparatively limited extent. The Devonian rocks contain much carbon in the form of bituminous shales and it has been suggested that there may be more carbon in the Devonian than the Carboniferous. These rocks are well developed in New York but the vertebrate life of the system is better shown in other states.

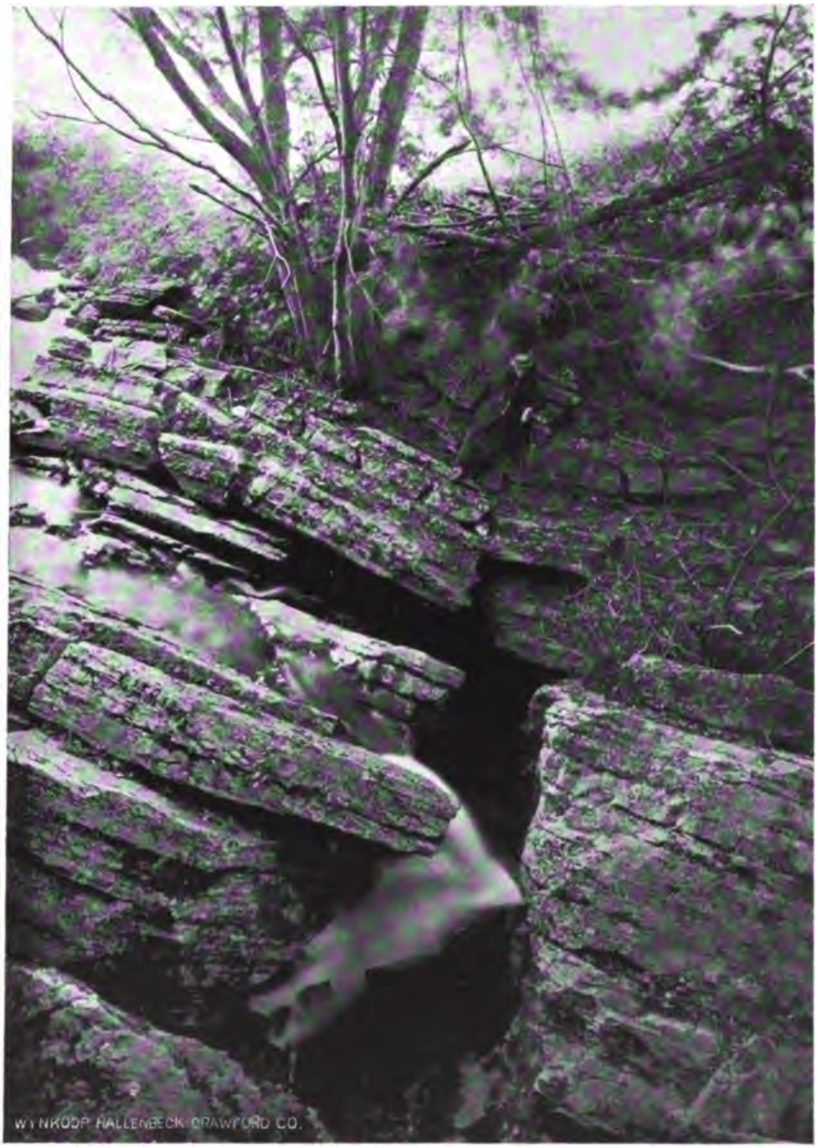
System	Group	Stage
Devonian	Chemung	
	Portage	Gardeau shales
		Cashaqua "
	Hamilton	Genesee "
		Tully limestone
		Moscow shale
		Encrinal limestone
		Ludlowville shale
		Marcellus "
	Corniferous	Corniferous limestone
		Onondaga "
		Schoharie grit
	Oriskany	Cauda Galli grit
		Oriskany sandstone

PLATE LXVII.—To face page 158.



HELDERBERG ESCARPMENT, WEST MOUNTAIN, SCHOHARIE, FROM A PHOTOGRAPH BY N. H. DARTON.

PLATE LXVIII.—To face page 158.



N. H. Darton, photo.

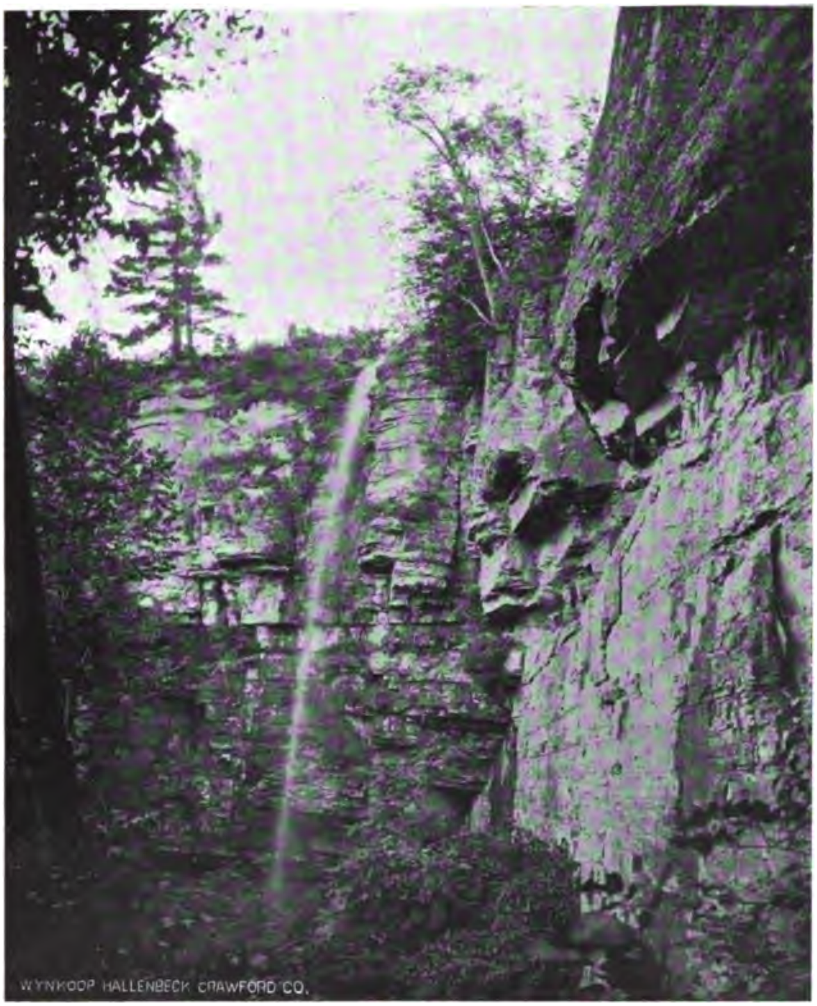
SINK IN THE LOWER HELDERBERG LIMESTONE WEST OF COXSACKIE, GREENE CO.

PLATE LXIX.—To face page 158.

S. R. Stoddard, photo.

INTERIOR OF HOWE'S CAVE, SCHOHARIE CO., SHOWING SUBTERRANEAN STREAM, STALACTITES, ETC LOWER HELDERBERG LIMESTONE.

PLATE LXX.—To face page 158.



N. H. Darton, photo.

CLIFF OF LOWER PENTAMERUS LIMESTONE, NEAR INDIAN LADDER, ALBANY CO.

Oriskany sandstone

This rock which overlies the Lower Helderberg group, is, at Oriskany Falls, whence it derives its name, a coarse light colored sandstone about 20 feet thick. In localities further west it is sometimes, as at the falls of the Chittenango creek and at Split Rock near Syracuse, either wanting or represented only by a few inches of dark sandy rock; sometimes, as between Elbridge and Skaneateles, 30 feet thick; and in other localities, of various intermediate thicknesses. Near Schoharie, it contains some lime with its sand, and is light colored; in some parts of the Helderberg region, as near Clarksville, and Knox, it is only a foot or two thick, a hard, dark colored stratum full of fossils and having[a] on its upper surface myriads of impressions of the Spirophyton cauda galli. In Pennsylvania, it is from 150 feet to 300 feet in thickness, and contains the same organic remains which are found in it in New York.

Cauda Galli Grit

Above the Oriskany sandstone, in the Helderberg region, is a mass of sandy slate or shale, often more than fifty feet thick; but it is not known west of Herkimer county. In Pennsylvania, it is seen from the state line to the Water Gap. It is valuable as a road metal though not very durable and forms, by decomposing, a poor soil. It is equally barren in fossils, the only form known being what is called the Cocktail fucoid, Spirophyton cauda galli, supposed to be the remains of a marine plant, the form of which resembles the peculiar plumage from which it is named. The abundance of this fossil has given the rock in which it lies the name of 'Cauda galli grit.[b]

Schoharie Grit

Upon it lies the Schoharie grit, a thin mass, usually only four or five feet of hard calcareous sandstone, which, when freshly quarried, looks like a gray limestone, but when long weathered,

a This important fact is not noted by either Mather or Lincklaen though it must have been observed by them. F. J. H. M.

b As I have noted under Oriskany, this fossil is not confined to the Cauda galli and occurs on the Oriskany sandstone. F J. H. M.

loses its carbonate of lime and becomes a gritty yellowish sandstone. It is found only from Cherry Valley eastward, extending round the front of the Helderbergs and along the hills west of the Hudson, but does not appear to be known in Pennsylvania.

Upper Helderberg or Corniferous Limestone

This which lies above the Schoharie grit, Cauda galli grit and Oriskany sandstone, and where these are wanting, together with the Lower Helderberg, as in western New York, rests immediately on the waterlime group, is one of the most widely known and useful limestones of the state. The lower portion, from 10 to 20 feet in thickness, is generally a coarse-grained crystalline gray rock, and, when free from chert, working well under the hammer and chisel, and often taking a good polish as a marble. It is called, from being very extensively quarried in Onondaga county, the Onondaga Limestone. It is easily traced from near Rondout on the Hudson to the Helderbergs in Albany county, where its outcropping edge turns westward, and extends past Schoharie, Cherry Valley, Bridgewater, Oriskany falls, the falls of the Chittenango below Cazenovia, Split Rock, Auburn, Phelps, Le Roy, and Williamsville to Black Rock. Through nearly all this distance it preserves its well marked character, and is extensively used in building.

The upper portion of the group is what was originally called the Corniferous limestone, from its containing beds and nodules of hornstone or chert: it is usually from 30 to 50 feet thick, a bluish or grayish rock, often having some shale interstratified with it. Though these two portions of the Upper Helderberg limestone are in most places very distinct, yet in others, especially in the west, they seem to run together or blend in one mass; so that they are now regarded only as local varieties of a single rock.

Upper Devonian Rocks

In the Upper Helderberg group, we have the last or highest formation of limestone of any considerable extent or thickness in the state. All the southern counties, lying above or south of

I. P. Bishop, photo.

CORNIFEROUS LIMESTONE, CAYUGA CREEK, BELLEVUE, ERIE CO. THE SURFACE SHOWS THE DISSOLVING ACTION OF WATER.

the line of outcrop of the Onondaga and Corniferous limestones as before described, are nearly destitute of this useful rock; being formed of vast deposits of slaty, shaly, and sandy strata, several thousand feet in thickness, the exposures of which extend southward from a few miles south of the Erie canal to beyond the Pennsylvania line.

These rocks give rise to peculiarities in the topographic features of the country which they underlie, and in its soil and vegetable productions. Containing little lime, the culture of wheat does not generally succeed well upon them; nor does the central wheat growing district extend over them for more than a few miles south of the limestone range, except in a few alluvial valleys, or places where calcareous materials from the limestone belts have been strewed over the southern shales by glacial action, of which we shall speak hereafter. Grazing and dairying are almost exclusively the pursuits of the farmer.

The most marked physical features of this great extent of country are its deep valleys and long hills, usually extending in a north and south direction, as an inspection of any map will show. Some of these long north and south valleys dammed by drift deposits are the basins of that remarkable series of lakes beginning with Otsego, and comprising Canaseraga, Cazenovia, Otisco, Skaneateles, Owasco, Cayuga, Seneca, Crooked, Canandaigua, Honeoye, Canadice, Hemlock, and Conesus; all so similar in general form and direction, and in the shape and geological formation of their enclosing hills. Over the whole extent of these rocks, the country is 'rolling,' or broken into ridges generally running north and south, and rising from one to eight hundred feet above the main valleys; and it is rarely that we find among them a plain half a mile wide, except in a few of the 'bottom-flats' or alluvial lands along the larger rivers, such as the Genesee.

These rocks are generally quite uniform in their character, especially in the eastern part of the state near the Hudson valley, and might be grouped into one enormous formation 5,000 feet or more in thickness, except for a few variations in texture, and

some more marked differences in the fossils of their lower, middle, and higher portions, on account of which they have been separated and described under the successive divisions of the Marcellus, Hamilton, Genesee, Portage, Chemung and Catskill.

Hamilton group

The Hamilton group, named from its exposure at Hamilton, Madison county, consists of the following sub-divisions.

Group	Stage	
Hamilton	Genesee	
	Tully	
	Hamilton	Moscow shale Encrinal limestone Ludlowville shale
	Marcellus	

Marcellus Shale

The lowest division, resting immediately on the Upper Helderberg limestone, was named from the village of Marcellus, near which it is well exposed. It is a mass of dark, fissile, short-fractured shale, one or two hundred feet in thickness, in most places containing layers of impure limestone and rounded concretions of similar material in its lower part.

At the village of Stafford in Genesee county, a thin limestone is well exposed about 40 feet above the base of the Marcellus. It has been called by Prof. J. M. Clarke, the Stafford Limestone, and extends from central New York to Lake Erie.

In Onondaga county the Goniatite limestone replaces the Stafford limestone.

These shales closely resemble those of the coal formation and sometimes contain thin seams of coaly or bituminous matter, which have misled many persons to spend considerable sums in digging and boring in them, with the illfounded expectation of finding useful layers of coal. This is an idle hope, for they lie thousands of feet below the Carboniferous system, beneath which no valuable coal strata have ever been found.

PLATE LXXII.—To face page 162.

I. P. Bishop. photo.

MARCELLUS AND HAMILTON SHALES, ATHOL SPRINGS, SHORE OF LAKE ERIE, ERIE CO.

PLATE LXXIII.—To face page 162.

Hamilton.

Marcellus.

I. P. Bishop, photo.

CLIFF OF DEVONIAN SHALES, SHORE OF LAKE ERIE, NEAR BAY VIEW, ERIE CO.

PLATE LXXIV.—To face page 162.

I. P. Bishop, photo.

EXPOSURE OF DEVONIAN SHALES, GORGE OF EIGHTEEN MILE CREEK, ERIE CO.

Genesee.

Styliola layer.

Moscow shale.

Encrinal limestone.

I. P. Bishop, photo.

UPPER DEVONIAN ROCKS, GORGE OF EIGHTEEN MILE CREEK, NEAR LAKE VIEW, ERIE CO., ¼ MILE BELOW THE L. S. & M. S. R. R. BRIDGE.

PLATE LXXVI.—To face page 162.

Encrinal limestone.

I. P. Bishop, photo.

HAMILTON SHALES, SHORE OF LAKE ERIE, AT THE MOUTH OF EIGHTEEN MILE CREEK, ERIE CO.

PLATE LXXVII.—To face page 162.

Genesee.　Moscow shale.　Encrinal limestone.

Hamilton.

I. P. Bishop, photo.

DEVONIAN ROCKS. WANAKAH. SHORE OF LAKE ERIE, ERIE CO.

PLATE LXXVIII.—To face page 162.

N. H. Darton, photo.

DEVONIAN STRATA, HONK FALLS, NEAR NAPANOCK, ULSTER CO.

Hamilton Shale

The Marcellus shales change gradually at their higher part into the Hamilton shale which is a harder, lighter colored mass, often containing sandstones, and, in central New York and as far east as the Catskill range, is 1,000 feet or more in thickness. Like the Marcellus shale, many parts of it show few marks of stratification; but it is divided vertically by joints, which, where it is excavated, are often as upright and smooth as the walls of a plastered building. In the more eastern part of the state, it is generally coarse-grained and sandy; in western New York, it is fine-grained, soft and more calcareous, forming by its decomposition a rich soil.

In the survey of the fourth district Hall divided the Hamilton into three parts; at the base the *Ludlowville shale*, overlaid by the *Encrinal limestone* and at the summit the *Moscow shale*. The Ludlowville and Moscow horizons take their name from localities in western New York. The Encrinal limestone is named from its prevailing fossil.

Tully limestone

The Hamilton group terminates in central New York with a very impure dark limestone, about 10 feet thick, which received its name from the village of Tully in Onondaga county. In the eastern and western parts of the state this rock does not exist, as it extends only from Ontario county to Madison, and beyond these limits the Genesee slate lies directly on the Hamilton group. The Tully limestone contains some fossils which are common to it and the lower shales.

Genesee

The next rock in upward order is the Genesee, a series of layers of thin-bedded, fissile, black slate, in some places 150 feet thick, but diminishing westward so that it is only about 25 feet on Lake Erie. It is, however, distinctly recognized in Pennsylvania, where it is some 300 feet thick. It derives its name from one of its best localities in this state, the gorge of the Genesee river

below Portage. It is generally recognized by its black, soft, slaty texture, but its fossils are very rare.

Portage group

This name has been given to the next higher portion of the great slaty and shaly masses, which form the walls of deep gorge of the Genesee at Portage and cover everywhere on the south the Hamilton group and Genesee slates. This enormous pile of sandy, slaty and shaly strata is in some parts of the state 1,000 feet in thickness: it was divided by Prof. Hall into a lower mass called the Cashaqua shale, a middle mass called the Gardeau shale and flagstones, and a terminal mass of sandstones seen at Portage; but in middle and eastern New York, these divisions are not distinct.

Much of this group is a soft olive-colored shale; but its most useful portions are its layers of flagstone, which are largely quarried near Norwich and Ithaca, on the hills back of the Helderbergs, on those west of the Hudson river as far down as Rondout; and in Sullivan county near the Delaware river.

From Chenango and Broome counties eastward to Greene county the Portage is represented by the Oneonta formation which forms the lower 1,000 feet of the Catskill mountain strata.

The soft shales of the Portage group contain many of the concretions known as *Septaria*, which also occur in the Marcellus shales.

Chemung group

To the Portage succeeds the Chemung, so called from being well exhibited at the 'Narrows' of the Chemung river, near Waverly, in Tioga county. Its thickness of 1,000 or 1,500 feet is made up of a series of thin-bedded sandstones with intervening shales and occasional beds of impure limestone mainly formed by the materials of fossil shells. In many places it abounds with fossils. While well developed in central and western New York the Chemung, as a group of fine sediments, disappears to the eastward and is represented by the Catskill formation.

PLATE LXXIX.—To face page 164.

I. P. Bishop, photo.

ERODED DEVONIAN SHALES, SHORE OF LAKE ERIE, MOUTH OF PIKE CREEK, NEAR DERBY, ERIE CO.

PLATE LXXX.—To face page 164.

Cashaqua shale.

Genesee shale.

L. P. Bishop, photo.

HAMILTON AND PORTAGE SHALES, SHORE OF LAKE ERIE, MOUTH OF PIKE CREEK, NEAR DERBY, ERIE CO.

PLATE LXXXI.—To face page 164.

R. S. Tarr, photo.

LOWER PORTAGE SHALES, TRIPHAMMER FALLS, ITHACA, TOMPKINS CO.

PLATE LXXXII.—To face page 164.

I. P. Bishop, photo.

BLACK SHALES, PORTAGE GROUP, PIKE CREEK, NEAR WEST FALLS, ERIE CO.

PLATE LXXXIII.—To face page 164.

14″ x 13″

18″ x 16″

Clay Iron Stone Concretions, Portage Group, Shore of Lake Erie.

PLATE LXXXIV.—To face page 164.

N. H. Darton, photo.

VIEW OF THE WITTEMBERG RANGE, SOUTHERN CATSKILLS, FROM A POINT HALF A MILE EAST OF SHOKAN STATION, ULSTER CO., LOOKING WEST.

Catskill group

The Chemung passes or changes eastward into the Catskill, an enormous series of shaly and sandy strata, which covers all the upper range of the Catskill mountains, and many of the higher tracts of the southern counties as far west as Steuben. In the latter county it is only a thin mass of calcareous sandstone, and farther west it thins out and disappears entirely; but in the Catskill region it is probably 2,500 feet thick, and twice as much in Pennsylvania; whence it is found southward along the mountain ridges, but in thinner volume.

The beds of this series are varied in color, being greenish gray sandstones, fine-grained reddish sandstones, slates, shales, grindstone grits and an accretionary mass appearing like fragments of hard slate cemented in calcareous rock. The hard sandstone often weathers in a peculiar way, dividing into thin layers almost like piles of boards.

The fossils of this rock are very few. Recent studies of this group suggest that it is not entitled to distinct recognition but is equivalent to the Chemung and perhaps to the Portage. Remains of plants are numerous, forming occasionally tiny seams of coal; and in some localities are teeth, bones and scales of fishes. The latter are often conspicuous objects, as they are usually white or bluish in color, and contrast strongly with the red rock.

Life of the Devonian

In the Devonian is observed a marked general advance in the character of life on the globe.

Sponges were few. Brachiopods were varied and numerous. Mollusks were abundant. Corals were highly developed and very numerous.

Fishes were the dominant type and appear to have supplanted the immense cephalopods which ruled in the Lower Silurian seas.

Plant life was well represented on land, especially by ferns. Conifers also existed.

The abundant flora which gave rise to the coal formations of the Carboniferous first became prominent in the Devonian.

CARBONIFEROUS SYSTEM

This system took its name from the fact of its being the chief coal bearing formation of Europe.

The Carboniferous is not well represented in New York; some of the uppermost sandstones, shales and conglomerates near the Pennsylvania boundary are undoubtedly of this age, but they contain no fossils.

In the endeavor to identify the Carboniferous strata of New York, it has been necessary to take up the known strata of this age in Pennsylvania and trace them, so far as possible, into New York.

The gradation from the rocks of the Devonian to those of the Carboniferous is not abrupt. On either side of the assumed boundary plane are greenish gray shales and sandstones without distinctive characters. For the present purpose it is necessary to describe the succession of the Pennsylvania rocks and indicate their occurrence in New York.

Sub-Carboniferous, Pocono group

Above the uppermost Devonian sandstones lie the rocks which are considered to be the base of the Carboniferous system. They are mainly sandstones with occasional beds of conglomerate. This conglomerate is said to occur on some of the peaks of the Catskills, but it has not yet been recognized in southwestern New York.

Sandstones of Pocono age doubtless occur in New York near the Pennsylvania boundary but they have no fossils.

The Pocono formation attains a thickness of more than 2,500 feet in Pennsylvania on the Susquehanna river. Some thin seams of coal occur in it. It contains no fossils except fragments of plants.

Mauch Chunk group

The Pocono is succeeded by a formation called the Mauch Chunk group, which, in Pennsylvania, is about 3,000 feet in its greatest thickness, though far less in some districts. It is almost entirely composed of soft, red shales and argillaceous red sand-

stones seen in the northern counties and generally around the edges of the different coal fields. In southern Pennsylvania it includes limestones. This formation has not been recognized in New York.

Pottsville conglomerate

The Mauch Chunk red shale is covered by a thick series of strata, known as the Pottsville conglomerate. It is a gray and whitish conglomerate, in massive beds alternating with gray sandstones, and consists mainly of rolled and rounded quartz pebbles cemented with ferruginous sand into a solid mass. Some of its finer or more sandy layers often show lamination in a diagonal or slanting direction. It is 1,700 feet thick at its maximum and often contains one or more thin seams of coal; being the lowest horizon in which any considerable quantity of that mineral has yet been found. It is remarkably massive in its general appearance, the ledges often separating into huge blocks with wide fissures between, which have been fancifully compared to ruined cities. Such localities are to be seen in New York six miles south of Olean, seven miles south of Ellicottville and near Wellsville, where they are popularly called 'rock-cities.' This is locally known as the Olean conglomerate.

The 'rock cities' lie on high points not far from the Pennsylvania line and are simply remnants of the conglomerate left far north of the main body of the rock by the wear and tear of the elements, which, going on through ages, has worn away this massive stratum over a great extent of country. They are impressive monuments to the vastness of that erosion, which has left them in this isolated position and which will in the course of future centuries demolish them entirely.

This conglomerate is the highest and latest formed of all Palaeozoic rocks known within the limits of New York. In Pennsylvania it is the base of the 'Productive Coal-measures,' as the strata containing workable layers of coal are called. They are made up of thick beds of sandstones and black shale, with which the coal layers are interstratified. The coal strata are of all thicknesses, from a few inches up to 20 or even

100 feet, and are separated from each other by masses of rock from 10 or 20 to 200 or 300 feet thick, and are mined in various ways according to their situation.

Geologic investigation in all coal regions has led to the conclusion that the strata of coal are composed of vegetable matter, which during the Carboniferous epoch appears to have reached an enormous and luxuriant growth, and formed vast accumulations, which after being buried under the marine sediments of clay and sand which now form the shales and sandstones over them, underwent chemical changes which transformed them to their present condition. The proofs of this are found in the fact that the rocks above and below the coal seams are filled with vegetable remains, leaves, stems, roots, etc.; the trunks of the trees being in some places found still erect and standing upon their roots, but converted into coal; and that even the coal itself, though in most cases it is solidified into one mass so as to show no organic structure, displays in other instances, under the microscope, all the structure of wood; the cells, the ducts through which the sap once circulated, and even minute markings by which it can be determined whether the wood belonged to one or another general class of trees.

The vegetable origin of all coal is well established; but the mode in which great accumulations of it were made, over such vast areas, is yet an obscure question. A single bed of coal, that called the Pittsburgh seam, is known to extend over no less than 14,000 square miles, with a usual thickness of from four to ten feet. Other layers, though less in extent, are much greater in thickness, reaching even 100 feet. The prevailing opinion is that it grew in enormous morasses or swampy tracts, resembling on a larger scale the Great Dismal swamp, or the Okefinokee swamp of Georgia, in which the annual fall of leaves, branches, and trunks through a long period of time formed thick peaty masses, which, being submerged under the sea and covered with sediments, became the vast deposits of fossil fuel which are now of so great importance.

The fossils of the coal measures are almost entirely vegetable. In the slates above the coal seams, most perfect and beautiful impressions of leaves occur in profusion; and large trunks or stems are found, almost always compressed to a thickness of only an inch or two, though two feet or more in width. The greater part of these trees seem to have been allied to the tree-ferns of tropical climates, though there are remains of coniferous trees and several other vegetable families. The character of this fossil vegetation would seem to indicate that at the time it grew, a far warmer climate than that now known prevailed over the temperate and arctic zones.

The fact that coal is of vegetable origin, seems to explain why the lower rocks which form the state of New York contain no coal. *They appear to have been formed before terrestrial vegetation flourished to an extent sufficient to form accumulations of this substance.*

The first relics of land plants are found in the Upper Silurian; above this they become more numerous and in the Catskill group of the Devonian are quite abundant, forming occasionally miniature coal seams an inch thick.

In the Carboniferous rocks they increase suddenly to an enormous quantity, and in later formations are found in considerable, but generally in less abundance. Coal is also found in newer rocks, such as the Jurassic, Cretaceous and Tertiary. The coal or lignite beds of the central part of the continent near the Rocky mountains, belong to the Cretaceous and Tertiary rocks. The coal of Vancouver island on the Pacific coast is Cretaceous. The coal beds near Richmond, Virginia, are of Triassic age. The conclusions to be drawn from our present knowledge are that good coal is found *above* the Carboniferous system, but *never below it.*

Permian

This formation which is well developed in Europe, taking its name from the Province of Perm, in Russia, is not known to exist in New York state. It occurs in Texas and its vicinity. It has been suggested that some of the uppermost deposits commonly

known as Carboniferous in Pennsylvania, should be referred to this horizon.

Life of the Carboniferous

Animals

Foraminifera were abundant. Sponges were well represented. Reef building corals were scarce. Crinoids were abundant.

Brachiopods were large and numerous.

Mollusks were prominently represented by cephalopods.

The fishes of the Carboniferous were very numerous and were principally sharks and ganoids.

The presence of amphibians was the prominent feature in the life of the Carboniferous; their bones occur in the coal measures. The largest were about the size of alligators.

Before the close of the Carboniferous, reptiles appeared.

Plants

Vegetable life was well represented by ferns, lycopods, equisetae, conifers and cycads. These were the plants which supplied the vegetable tissue which forms the coal beds.

Mesozoic Time

The Mesozoic presents a marked contrast to the Palaeozoic. The sea was peopled with fishes. Cephalopods were most prominent among the mollusks. True reptiles which appeared in the Permian were large and numerous and reached their highest development. Mammals appeared as a new element but held a subordinate position. They were at first quite small.

There was a complete change in the vegetation. Sigillaria and calamites disappeared and the age of gymnosperms succeeded that of acrogens or pteridophyta.

Arborescent conifers were very large and abundant. The cycads occupied the place of the palms of the present day.

The Mesozoic series includes the *Triassic*, *Jurassic* and *Cretaceous* systems.

TRIASSIC SYSTEM

This system received its name in Germany where it consists of three distinct members. In England it is known as the New Red Sandstone and contains the salt deposits of that country. West of the Mississippi river the Triassic is well represented in the United States, but in the east it is found only in narrow troughs on the east side of the Appalachian chain and approximately parallel to it. It is well developed in the Connecticut valley and is again found near Stony Point, New York, from which locality it extends southwest across Rockland county into New Jersey, thence through Pennsylvania and Virginia. In the latter state it includes the Deep and Dan river coal basins which are of considerable importance.

The Triassic deposits of New York and New England were apparently formed in estuaries and consist of shales and sandstones. These bear ripple marks, sun cracks, rain prints and the foot prints of enormous biped reptiles with three toes. These were at first supposed to be bird tracks. Fishes are also abundant in the sandstones of New York and New Jersey.

The eastern Triassic rocks are important as having furnished the greater part of the brown sandstone, which is used so extensively for building houses in our eastern cities. The Triassic period was also characterized by eruptions of igneous rock, which formed the well known trap dykes of Connecticut and New Jersey. In the latter state the most prominent is that known as the 'Palisades of the Hudson,' which extend along the west shore of the Hudson river from Staten Island to a point northwest of Nyack. At the level of the river the rock is a nearly horizontally stratified red sandstone; but between the bedding planes a vast volume of melted rock has been injected, and in cooling has assumed the rudely crystalline or columnar structure so common in basaltic or trap rocks. The broken edge of this enormous sheet of trap, fronting on the river, forms the precipice so well known as 'the Palisades.' The Orange mountains are also of the same formation.

Life of the Triassic period

In the Triassic was the reign of the amphibians, some of which were very large. The most highly developed was the labyrinthodon, which had the form of a frog and was as large as an ox. Reptiles were very large and numerous but their remains are more abundant in Europe than America. The mammalian fauna was insignificant; fishes were numerous; mollusks were abundant, but were not a prevailing type.

JURASSIC SYSTEM

The connection between the Triassic and Jurassic is very close and the passage is very gradual. The Jurassic takes its name from the Jura mountains of France and Switzerland, which are chiefly composed of the rocks of this age. In eastern North America the Jurassic is moderately developed, and it is considered that a part of the Triassic sandstone, already described, may have been deposited during this age.

West of the Mississippi the Jurassic is well developed.

Life of the Jurassic period

The Jurassic was especially characterized by the prominence of reptilian life which appeared in a great variety of forms and occupied every place in nature. Reptiles were large and numerous, in the ocean and on land. Even in the air immense lizards with wings like those of a bat were abundant. In this age the first of the birds appears. This was the *archaeopteryx*, found in the slates of Solenhofen, Germany, a bird which was rudimentary in its development. The wings were short and also the wing feathers which were radiated. The tail was vertebrated and the vertebrae bore feathers. It had no teeth. The sharks and ganoid fishes were large and abundant. The mammals were numerous, but subordinate in rank, not being larger than rats and opossums.

In this system also was the culmination of the ammonite family, a group of coiled cephalopods named from their resemblance to the horns on the statues of Jupiter Ammon. As the cephalo-

PLATE LXXXVI.—To face page 172.

H. Ries, photo.

Triassic Conglomerate, Stony Point, Rockland Co.

PLATE LXXXVII.—To face page 172.

Triassic Diabase

H. Ries, photo.

VIEW NORTHWARD ALONG THE PALISADES OF THE HUDSON RIVER, FROM FORT LEE, N. J.

PLATE LXXXVIII.—To face page 172.

Triassic Diabase.

S. R. Stoddard, photo.

THE PALISADES OF THE HUDSON. VIEW NORTHWARD FROM ENGLEWOOD CLIFFS, N. J.

PLATE LXXXIX.—To face page 172.

J. N. Nevius, photo.

TRIASSIC DIABASE EXPOSED IN A CUT FOR THE ORANGE MOUNTAIN CABLE-ROAD, ORANGE, N. J.

H. Ries, photo.

Contact of Trap and Underlying Triassic Sandstone, South End of Lane's Quarry, Fort Lee, Bergen Co., New Jersey.

PLATE XCI.—To face page 172

J. N. Nevius, photo.

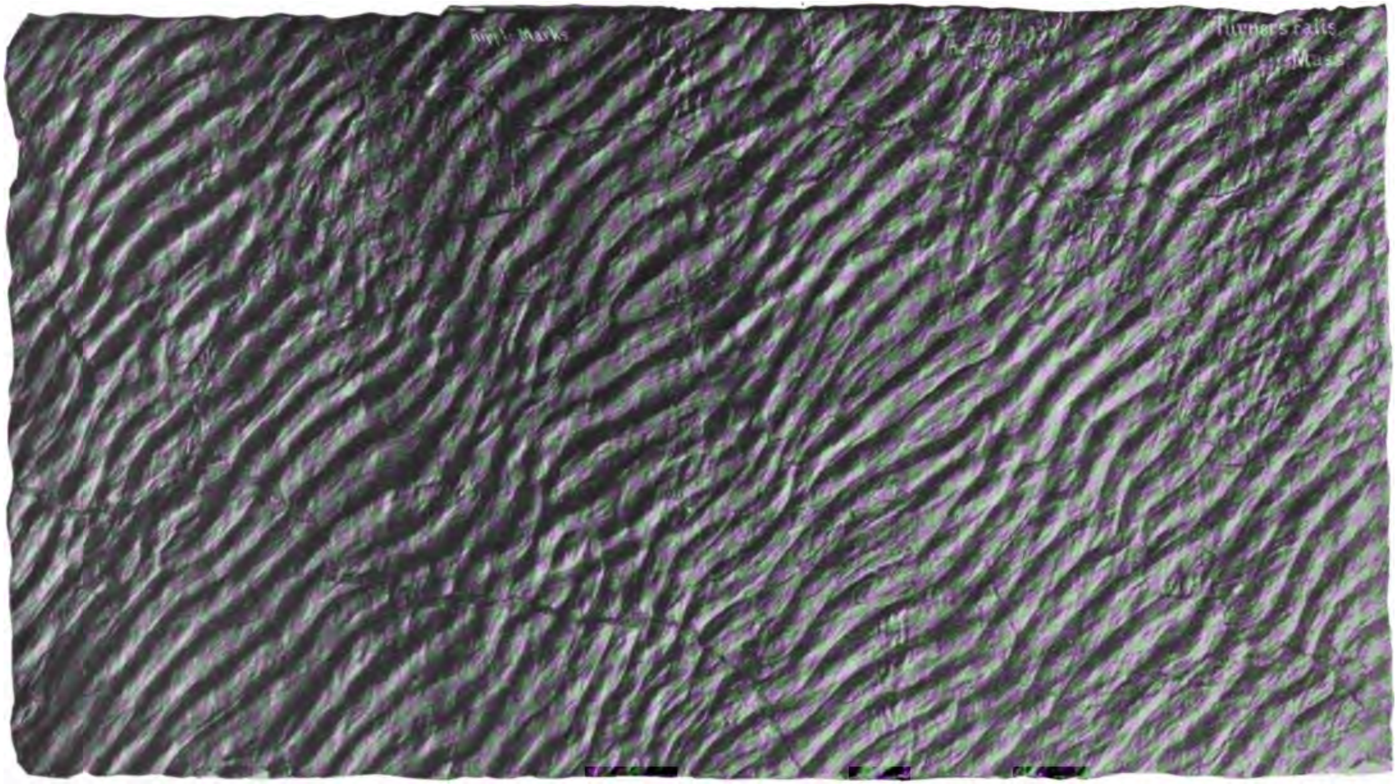
REPTILIAN FOOTPRINTS ON TRIASSIC SANDSTONE, TURNER'S FALLS, MASS. ORIGINAL SLAB 19 INCHES BY 27 INCHES.

PLATE XCII.—To face page 172.

J. N. Nevius, photo.

RAIN PRINTS AND REPTILIAN FOOTPRINTS ON TRIASSIC SANDSTONE, TURNER'S FALLS, MASS. ORIGINAL SLAB 33 INCHES BY 18 INCHES.

PLATE XCIII.—To face page 172.



J. N. Nevius, photo.

RIPPLE MARKS ON TRIASSIC SANDSTONE, TURNER'S FALLS, MASS. ORIGINAL SLAB 43 INCHES BY 24 INCHES.

pods were represented in great development by the orthoceras in the Lower Silurian seas, so were they represented by the ammonite in the Jurassic. The orthoceras disappeared after the Triassic age.

The smaller mollusks were also abundant and began to assume more nearly the features of those which occur at the present day. At this time the oyster made its appearance.

CRETACEOUS SYSTEM

The Jurassic system was succeeded by the Cretaceous. This received its name in Europe from the chalk formation, which in England and France is very prominent, being several hundred feet thick. The chalk is a limestone which has not been consolidated. If it had been exposed to the same agencies as the Palaeozoic limestones it would probably like them have been consolidated to form a hard rock. A large part of the chalk consists of skeletons and shells of foraminifera, some of the species being found in the ocean at the present day. With these foraminifera, which are mostly calcareous, are the remains of other minute animals called polycystines which are silicious and also the spicules of sponges. These, by some chemical action, have been gathered together and consolidated into nodules of flint which is a variety of quartz similar in composition to the hornstone of the Corniferous and other limestones. Hornstone is also called chert and has furnished the material for most of the North American Indian arrow-heads which are commonly called flint arrow-heads. As a matter of fact the true flint does not occur in America and technically American flint arrow-heads are made of chert or hornstone. It is not impossible, however, that early traders from England may have supplied our Indians with flint from Europe.

In America there is but little chalk, although the Cretaceous system is largely developed. It extends from the Gulf of Mexico to the Arctic ocean in a belt 200 miles wide. On the Atlantic coast Cretaceous deposits are found beneath the Tertiary and consist chiefly of sand and clay. The clays which occur on Long

Island and are well represented from Staten Island to the vicinity of Camden, New Jersey, are important in the manufacture of pottery. Some of the clay beds contain plant remains and about 50 species of land plants have been recognized here. Among these are many genera which exist at the present day, such as the cinnamon, sassafras, oak, gum etc. The character of this vegetation suggests that a temperate climate prevailed in this region during cretaceous time. A little later, in the Tertiary, a sub-tropical climate prevailed in what are now the Arctic regions. West of the Mississippi the Cretaceous deposits of our country are divided into three principal groups; the *Dakota*, which consists of sandstone and conglomerate with beds of clay; the *Colorado*, a group of limestone and bituminous shales; and the *Laramie*, which is a bed of passage into the Tertiary and contains important deposits of lignite, a variety of coal.

Life of the Cretaceous period

In the Cretaceous, mammals were still insignificant. The members of the ammonite group of the cephalopoda, were numerous and varied in form. The other mollusks were closely allied to those of the present day. Many bony fishes appeared and supplanted the ganoid fishes which had previously prevailed. The reptilian fauna was prominent, but became greatly diminished before the tertiary. With the close of this period occurred a great change in the life of the globe.

Cenozoic Time

Following the close of the Mesozoic age begins the Cenozoic, which includes the Tertiary and Quaternary systems and is characterized by a marked resemblance of its life, to that of the present day.

TERTIARY SYSTEM

Sir Charles Lyell divided the European Tertiary into three parts; the Eocene, Miocene and Pliocene. The Eocene was estimated to contain about 10% of living species, the Miocene about 50% and the Pliocene about 90%, but these percentages are not of world wide application.

The Tertiary of our Atlantic slope consists chiefly of sands and clays, which in the southern states are well developed. A much larger development occurs west of the Mississippi river on the sites of extinct Tertiary lakes. Marine Tertiary is also found on the Pacific coast.

In New York state the Tertiary is not accurately identified and is indivisible, but is probably represented by sands and gravel on Staten Island and Long Island. There is comparatively little marine Tertiary in North America, as the northern part of the continent was out of water at that time. The Tertiary beds west of the Mississippi are chiefly fresh water deposits formed in lake basins. The Tertiary was a period of mountain making. In southern Europe the great chains of mountains known locally as the Pyrenees, Alps, Apennines and Carpathians, consist to a large extent of Tertiary rocks. This is also true of the Himalaya mountains of India. It is known that extensive disturbances in our Appalachian system occurred during the Tertiary.

Life of the Tertiary period

Birds and mammals succeeded the reptiles of the cretaceous. Of the mammals all the orders now existing were represented. Reptiles were not more numerous than at present and were similar to existing genera. Fishes were very abundant. Insects were many and varied. Mollusks were abundant; oysters occurred in great variety and of enormous size. Corals were not plentiful. Land plants were very abundant and very similar to those of the present day; the cypress grew in the Arctic regions.

QUATERNARY SYSTEM

At the close of the Tertiary a cold temperate climate reigned in the United States and a great ice age began, during which the northern part of our continent was covered with a sheet of ice many hundred feet thick. The chief evidences of this are the inscriptions of the continental glaciers on the rocks in the shape

of grooves and polished surfaces and the material transported by it.

The glacial phenomena are well marked. Ice worked blocks of stone have a peculiar angular form, which does not occur on water worn boulders.

The theory of continental glaciation was first worked out in Europe from studies of the glaciers of the Alps. These are the result of a copious precipitation of moisture on the mountains in the form of snow and the formation of snow ice. Large masses of this consolidate and form ice rivers or glaciers, which slowly move toward the valleys grooving and polishing the rocks over which they pass and tearing off rock fragments, which in turn are polished and scratched as they are dragged along in the base of the ice.

Glaciers now exist in Iceland, Greenland and Alaska and in other Arctic countries, also on some of the mountains of Washington, South America, Asia and Africa. They also abound within the Antarctic Circle.

Evidences of former continental glaciation occur in both hemispheres.

In New York state the continental glacier extended as far south as Long Island and Staten Island and formed at its front a great ridge of transported rock debris, sand, gravel, boulders and clay, at some points over 360 feet in height, which is called the 'terminal moraine' and is known locally as the back bone of Long Island.

After reaching its point of maximum extension and resting there, perhaps for a long time, the ice sheet with a recurrence of a warmer climate began to retreat. This retreat was not at an even rate. There were periods of arrested motion and probably of temporary advance as shown by the moraines of recession. These are masses of earth, gravel and boulders which form small hills and ridges.

As the ice melted, great volumes of water were poured over the land and the valleys were flooded. The streams thus formed were loaded with sand and gravel which they carried for a dis-

tance and dropped to form the flood plains and terraces which border our river valleys and the hills of sand and gravel in the valleys which are called kames and eskers. Where there were bodies of still water the finer máterials were dropped to form clay.

At this time the country was deeply submerged and tide water filled the valley of the Hudson river and Lake Champlain so that the Gulf of St Lawrence and New York harbor were united. This is evidenced by the fact that near the St Lawrence and Lake Champlain, above the gravel beds, are some beds of clay 200 feet thick or more, which contain marine shells of species now existing on the coasts of New England and Canada. These show that, since such shells were living, those valleys have been depressed below the sea-level, long enough for these deposits of clay to be formed. They are known as pleistocene clays. The Hudson river valley clays are their southern extension, but contain no fossils.

The Quaternary deposits of New York are, therefore, chiefly those made in the presence of the ice and those resulting from the working over of the glacial deposits by running water. In this latter process the angularity of the glacial boulders and pebbles has been worn off. The evidences of glacial action are well seen in almost all parts of this state. Almost every gravel-bank consists of waterworn fragments of the old rocky strata; pebbles of limestone, sandstone and slate, with some of gneiss and granite, which universally appear to have been transported from north to south. From a bushel of pebbles taken from any gravel bank south of the Erie canal, the geologist can pick out specimens of almost every stratum which is exposed north of the bed whence they were taken. South of the line of outcrop of the Helderberg limestones, the gravels are full of fragments of their different layers; and among them lie worn pieces of the red Medina sandstone, others of the Hudson river group, and others of still more northern strata; while some are granite pebbles, which must in many instances have come from Canada. They have evidently been transported from north to south in

vast quantities; they are smooth-worn, and are smaller the farther they are found from their original strata; theyare generally found in irregular layers with sand and clay, as if left so by the action of rapid currents of water. One of the most interesting facts connected with them is, that they have been in many cases transported from lower to higher levels, even up steep acclivities and over high hills. There are spread with them also (but generally lying on the surface of the ground) many large and heavy masses of loose rock, called boulders. Some of these are limestones or sandstones, the origin of which can easily be traced to thin native strata within the state; others are granitic masses, which must have come from beyond Lake Ontario, in the same manner that the peculiar crystalline rocks of the Adirondack mountains are found to have been carried south beyond the Mohawk valley. The surfaces of the rocky strata in all the country, over which these 'drift beds' have passed, are in many places found to be worn smooth, and scratched or furrowed in a general north and south, or northwest and southeast direction, as if heavy materials had been dragged or driven over them.

Quaternary fossils

Among the most recent of the fossil remains, which link together the vanished forms of the past with the living animals of to-day, are the bones of the mastodon and fossil elephant, which are occasionally disinterred in various parts of the state, found buried only in recent accumulations of muck, peat, or other earthy materials. They are relics of a very modern period of geologic history, and these immense animals seem to have lived during the existence in this region of many of our still-remaining wild animals; possibly even since it was inhabited by man. Specimens of the mastodon have been found at Cohoes, at Batavia and in Orange county. In addition to these may be mentioned the *Castoroides ohioensis*, a gigantic extinct species of beaver, which was probably of the same period with the mastodon. A skull of this species was found near the village of Clyde, in earth, during the excavation of a canal. Remains of a reindeer have been found at Sing Sing.

PLATE XCIV.—To face page 176.

I. P. Bishop, photo.

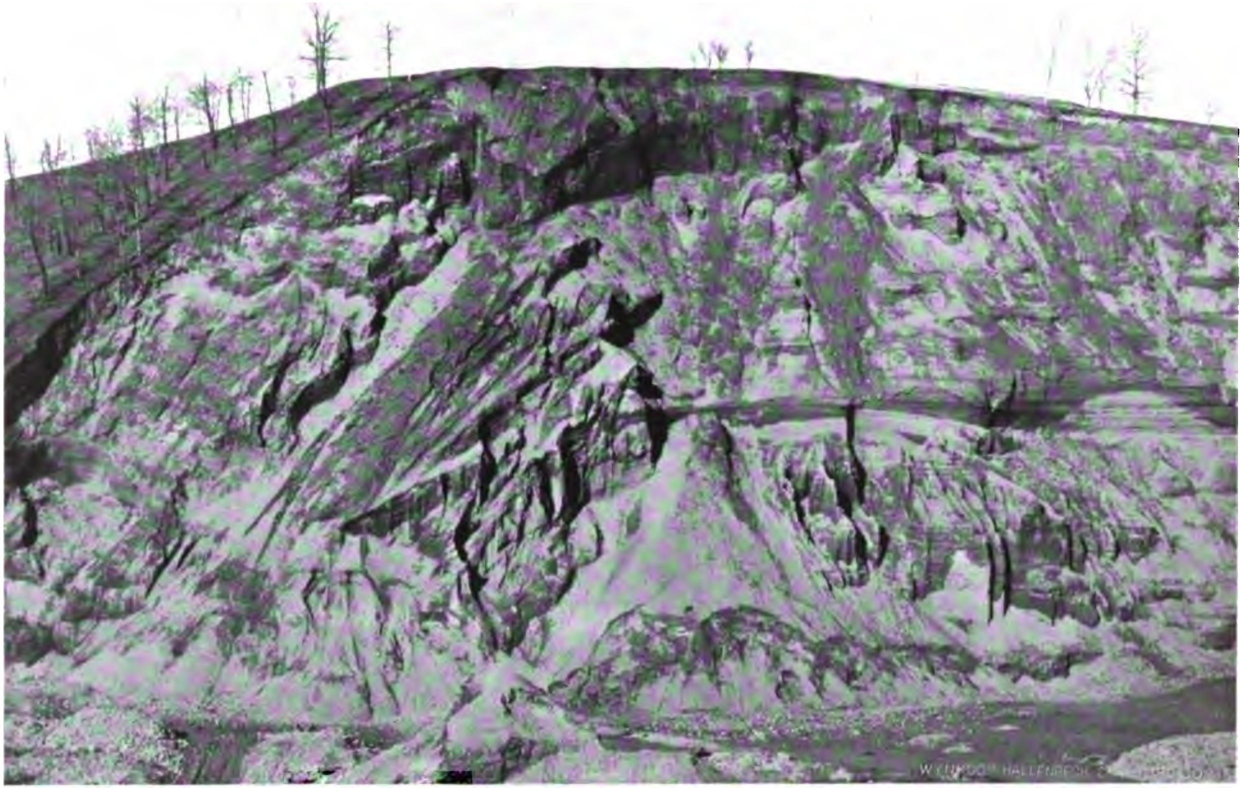
GLACIAL SCRATCHES ON THE CORNIFEROUS LIMESTONE, CHEEKTOWAGA, ERIE CO.

PLATE XCV.—To face page 176.

H. Ries, photo.

QUATERNARY DELTA DEPOSIT OF CROTON RIVER, 1 MILE SOUTH OF CROTON LANDING, WESTCHESTER CO.

PLATE XCVI.—To face page 176.



J. N. Nevius, photo.

VIEW OF QUATERNARY KAME DEPOSIT, NORTH ALBANY, ALBANY CO.

PLATE XCVII.—To face page 176.

J. N. Nevius, photo.

SECTION OF QUATERNARY SAND AND GRAVEL BEDS, NORTH ALBANY, ALBANY CO., SHOWN IN LAST ILLUSTRATION.

PLATE XCVIII.—To face page 176.

J. N. Nevius, photo.

VALLEY OF EROSION, IN THE QUATERNARY SAND PLAIN, NEAR DELMAR, ALBANY CO.

PLATE XCIX.—To face page 176.

N. H. Darton, photo.

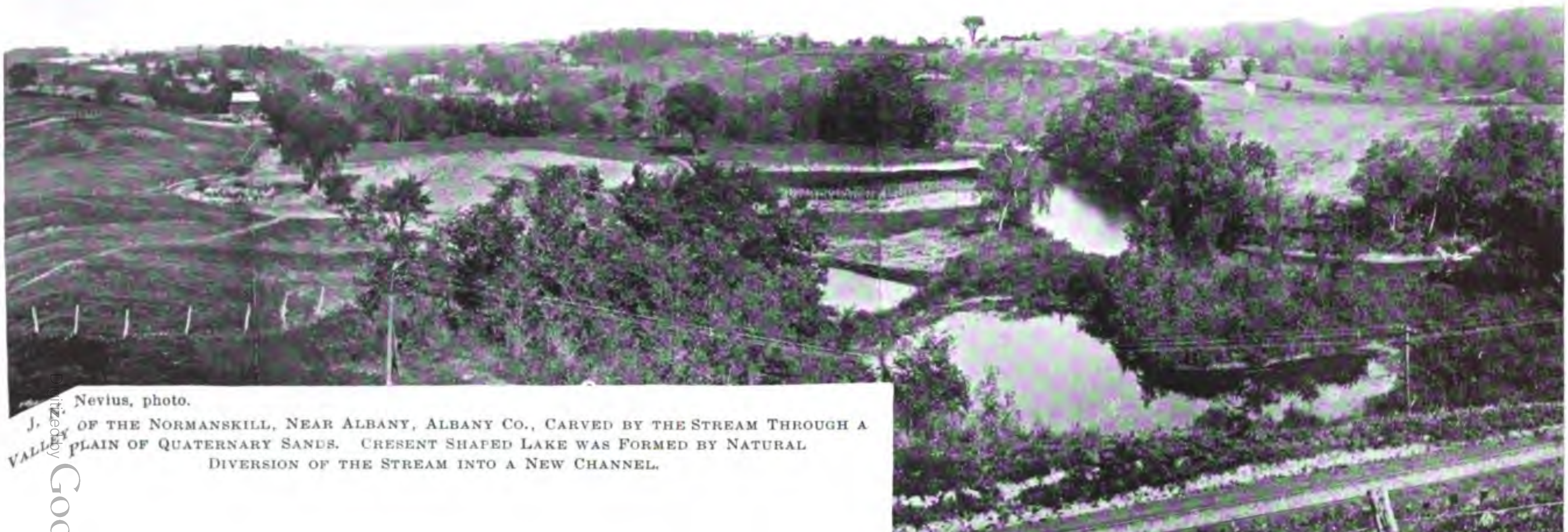
LAKE IN QUATERNARY DRIFT HILLS SOUTHWEST OF GLENS FALLS, WARREN CO. FRENCH MOUNTAIN IN THE DISTANCE.

PLATE C.—To face page 176.

H. Ries, photo.

QUATERNARY PLAIN AT THE FOOT OF THE HELDERBERG ESCARPMENT, BETWEEN RAVENA AND SOUTH BETHLEHEM, ALBANY CO.

PLATE CI.—To face page 176.



J. N. Nevius, photo.

VALLEY OF THE NORMANSKILL, NEAR ALBANY, ALBANY CO., CARVED BY THE STREAM THROUGH A PLAIN OF QUATERNARY SANDS. CRESENT SHAPED LAKE WAS FORMED BY NATURAL DIVERSION OF THE STREAM INTO A NEW CHANNEL.

PLATE CII.—To face page 176.

I. P. Bishop, photo.

SAND BARS, LAKE ERIE, MOUTH OF EIGHTEEN MILE CREEK, ERIE CO.

PLATE CIII.—To face page 176

I. P. Bishop, photo.

GLACIAL BOULDERS WASHED FROM MORAINE, STONY POINT, NEAR WEST SENECA, ERIE CO. SHORE OF LAKE ERIE.

PLATE CIV.—To face page 176.

S. R. Stoddard, photo.

FOOT OF THE SELKIRK GLACIER, BRITISH COLUMBIA, SHOWING THE FORMATION OF A MORAINE DEPOSIT.

The petrified wood, leaves, moss, etc., which are common in our limestone districts, are of modern date, and are forming at the present time. The rain-water which percolates through the crevices of the limestone rocks, by means of the carbonic acid which it gathers from the air, dissolves the carbonate of lime; and on coming again to the air in springs, re-deposits it in the form of tufa, a drab-colored mass which is nearly pure carbonate of lime. This, as it gradually forms, incrusts the leaves, sticks, etc., with which it comes in contact; and often, as they decay, replaces them in such a manner as to present the same form and structure; pieces of wood being thus replaced by a stony mass closely resembling the original substance.

Age of man

Man is the most highly specialized member of the animal kingdom. His remains are not found in deposits earlier than the post glacial, which appear to have an age of not many thousand years. There is, so far, no clue to his origin. The first relics of man are rude implements of stone or bone such as knives, arrow-heads, etc., and are found in the gravels of streams and in caves.

The first period of man is known as the stone age, but though it ceased long ago in Europe, in North America it has existed to within the present century. The bronze age succeeded the stone age. Last of all came the age of iron which is the present.

PRESENT SURFACE OF NEW YORK

Under this head it is important to consider briefly the causes which have reduced so large a portion of the rock strata of New York, from the original condition of the wide and uninterrupted extent in which they were formed to that of an undulating and broken aggregate of hills and valleys which we now see. It is probable that during the slow process of emergence from their native sea, the action of waves and currents wore them deeply

and extensively; and since they were uplifted to their present elevation, the elements have unremittingly acted upon them.

As the rocks, newer than the Carboniferous, occur in but small areas within our state, it may be concluded that the greater part of this region has been above water since the Carboniferous period, during the countless ages while the Triassic, Jurassic, Cretaceous and Tertiary rocks were formed and during the deposition of which the animated population of the earth has been changed many times. All of these formations were made of sediments worn from pre-existing land. It is to be expected, therefore, that this ancient land should show the marks of vast erosion and wear. Some marks of this are found in the long and deep valleys which traverse the state, all of which have been worn out of the solid strata, the remaining portions of which form the adjacent hills. These valleys are being worn deeper where the rivers are strong and their cutting action continues, and everywhere they are being widened and the mountains and hills reduced in height by rains and frost. Some valleys have been excavated much below the level of their present outlets, so that they retain the drainage and form the remarkable series of finger lakes previously mentioned.

Vast as the work may seem, the fact is plain that not only have these valleys been formed by erosion, but hundreds of feet of rocky strata have been removed from the summits of the hills themselves and from large tracts of plain country. The whole vast basin of Lake Ontario is an excavation in rocks which still lie nearly as level as when first deposited; and there seems no reason to doubt that the northern edges of the enormous thickness of formations above the Helderberg limestones once overspread the present lowlands of the counties bordering that great body of water.

Such long lines of bluffs as the Niagara 'mountain ridge,' and the steep escarpments of the Helderberg limestones, are evidences of the great work of erosion. The existence of old beaches, such as the Lake Ridge near Rochester, proves that the waters of the lake once stood far higher than now.

PART 3.

ECONOMIC GEOLOGY

BUILDING STONE [a]

GRANITIC ROCKS

Granite, Gneiss, Syenite, Trap and Norite

Granite. Typical granite is a crystalline, granular mixture of a feldspar, quartz and hornblende. In addition to these essential constituents, one or more accessory minerals may be present. The more common are the micas, muscovite and biotite, garnet, tourmaline, magnetite and pyrite. The character of the rock is often determined by the presence of these accessory constituents in quantity, as in some cases the hornblende is entirely replaced by mica.

The chemical composition also varies from that of the average or typical kind. The mineralogical differences mark the varieties, thus there are: hornblende granite, biotite granite, tourmaline granite, etc.

The texture of granites is determined by the aggregated minerals entering into their composition. It varies from coarse-crystalline, in which the individual crystals may be an inch or more in length, to fine-crystalline and aphanitic, wherein the minerals are hardly visible to the eye. In consequence of the wide variation due to the mode of arrangement of the mineral constituents, there is an equally great variety noticeable in the texture.

The color also is dependent upon the minerals. As feldspar is the predominant constituent it gives character to the mass, and the red varieties owe their color to the red or pink feldspars in them, as in the case of the granite of Grindstone Island in the St Lawrence. The shades of gray are due to the varying

[a] This chapter on building stone is abridged with alterations and additions from Bulletin No. 10 of the New York State Museum, by John C. Smock.

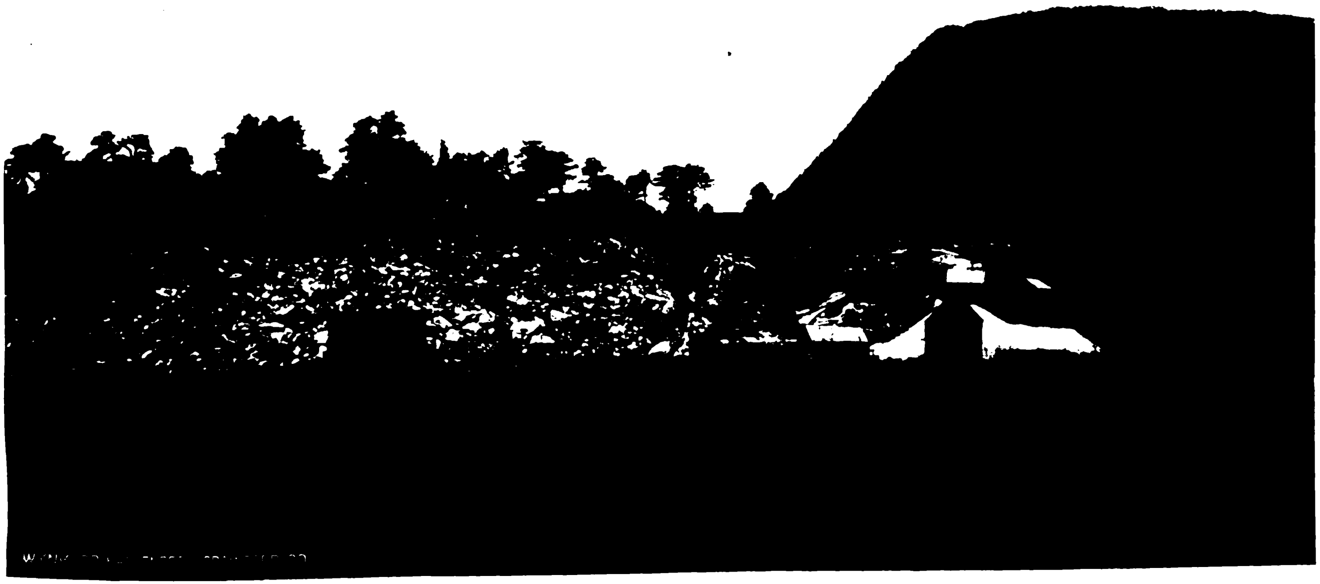
amount of the dark colored mica mixed with the feldspar and quartz; and the dark colored varieties owe their color, in most cases, to hornblende or tourmaline which may be present.

The beauty, ease of working, durability and value of the granites for use in construction is related closely to their mineralogical composition. Their arrangement in the mass and their relative proportions determine the color and give beauty. The presence or absence of certain species influence the hardness and homogeneous nature and the consequent ease with which the stone can be dressed and polished. For example the mica, if disposed in parallel surfaces, gives a foliated structure and tends to produce what is known as rift, and the granite is more readily split in the planes of the mica than across them. Again the mica flakes may be so large and irregularly massed that the surface is not susceptible of a uniform degree of polish. Hornblende, on account of its superior toughness, is less brittle than pyroxene under the polishing, and the hornblende granites are said to be preferred to those rocks which contain pyroxene in quantity.

The more nearly alike in hardness and the more intimately interwoven the texture of the minerals, the more capable they are of receiving a good polish. Hence it follows that the very coarse crystalline granites are not so well suited for ornamental work.

The enduring properties of granites vary with the nature of the minerals in their composition. Although popularly they are regarded as our most durable building stone, there are some notable exceptions, which are evident in the natural outcrops, where this rock is found decayed to the depth of 100 to 200 feet, and in the active disintegration which is in progress in structures of the present century. Foliated varieties placed on edge in buildings, tend necessarily to scale under the great changes of temperature in our northern cities and towns. The more rapid decomposition of the micas makes those varieties in which they occur in large flakes or aggregations more liable to decay. The condition of the feldspar also is often such as to influence the durability. When kaolinized in part, it is an element of weakness rather than of strength. The presence of the easily decom-

PLATE CV.—To face page 182.



H. Ries, photo.

GRANITE QUARRY, ROUND ISLAND, NEAR PEEKSKILL, WESTCHESTER CO. PRECAMBRIAN.

posable varieties of pyrite is not only prejudicial to strength and durability but also to the beauty of the stone as soon as it begins to decay.

The term 'granite' as used among builders and architects is not restricted to rock species of this name in geologic nomenclature, but includes what are known as gneisses (foliated and bedded granites), diorites, gabbro and other crystalline rocks whose uses are the same. In fact, the similar adaptability and use have brought the latter species into the class of granites. For example, the Au Sable granite of Essex county is a norite. The term is applied in some cases to the diabases or trap-rocks, as the 'granite quarries' of Staten Island.

Another massive crystalline rock which is used in building is norite, consisting of labradorite and hypersthene, with some brown mica. It is a common rock in the Adirondack region, and is known commercially as a granite.

The massive crystalline rocks are of common occurrence in New York, but not in outcrops over extensive areas, excepting in the Adirondack region and in the Highlands of the Hudson. The schistose crystalline rocks are developed extensively in the Highlands of the Hudson and on the borders of the Adirondack region. On New York island and within the city limits the gneiss rocks have been quarried at many points. In Westchester county there are belts of gneiss and mica schist, in which quarries have been opened near Hastings; near Hartsdale, east of Yonkers; at Kensico; at Tarrytown and at Ganung's, west of Croton Falls. In Putnam county there are quarries of granite near Peekskill, Garrison's and Cold Spring. West of the Hudson river there are quarries on Iona island; at West Point; on Storm King mountain, near Cornwall; near Suffern; at Ramapo; and on Mount Eve, near Florida. The outcrops of the gneissoid and granitoid rocks are so numerous in the belt of the Hudson Highlands that quarries can be opened at many points. The supply of stone is inexhaustible. On the Hudson river, between Peekskill and Fishkill, there is a fine section of these rocks exposed.

On the borders of the Adirondack region quarries have been opened in the towns of Wilton, Hadley and Greenfield, in Saratoga county; at Whitehall, in Washington county; at Littlefalls, in Herkimer county; Grindstone Island, Jefferson county; and near Canton in St Lawrence county. The inaccessibility of much of this region and the distance from the large city markets have prevented the opening of more quarries in the gneissic rocks on the borders of the Adirondacks.

TRAP

Trap-rock or trap is the common name given to a class of eruptive rocks because of a structural peculiarity, and has no distinctive significance in mineralogical composition. The rocks of the Palisade mountain range and of the Torn mountain, which extends from the New Jersey line, on the west shore of the Hudson river to Haverstraw, are known as trap-rocks. There is an outcrop on Staten Island, at Graniteville, near Port Richmond, where a large amount of stone has been quarried at the so-called 'granite quarries.'

The trap-rock of the Palisades range is a crystalline, granular mass of plagioclase feldspar (usually labradorite) augite and magnetite. It is generally finer crystalline than the granite. The colors vary from dark gray through dark green to almost black.

This trap-rock is hard and tough, but some of it is split readily into blocks for paving. It has been used extensively in New York and adjacent cities for street paving, but since the introduction of granite blocks this use has nearly ceased. On account of its toughness it makes an admirable material for macadamizing roadways. It is so hard that only rock-face blocks are used in constructive work. Several prominent buildings in Jersey City and Hoboken are built of it. There is a large quarry on the river at Rockland lake, near Haverstraw, the output of which is for street work and road material almost exclusively. There are also quarries at Piermont and at Graniteville, Staten Island.

SANDSTONE

Sandstone consists of grains of sand which are united by a cement.

The grains may be of varying sizes, from almost impalpable dust to small pebbles, and may be angular or more or less rounded in form. The cementing matter also may vary greatly in its nature. From this variation, both in the grains and in the cement, there is an almost endless gradation in the kinds of sandstone.

Quartz is the essential constituent, but with it there may be feldspar, mica, calcite, pyrite, glauconite, clay or other minerals, and rock fragments common to stone of sedimentary origin. These accessory materials often give character to the mass, and make a basis for a division into feldspathic, micaceous, calcareous sandstones, etc., as one or another of them predominates.

The texture of the mass also is subject to a wide range of variation, from fine-grained, almost aphanitic, to pebbly sandstone, or conglomerate, or a brecciated stone in which the component parts are more or less angular.

Some of the brown sandstones of the Triassic age, quarried near Haverstraw, are such conglomeratic and brecciated sandstones. Accordingly, as the grains are small or large, the stone is said to be fine-grained or coarse-grained.

The variety of the cementing material also affords a basis for classification. Silicious sandstones have the grains bound together by silica. They consist almost exclusively of quartz, and grade into quartzite. The ferruginous varieties have for their cement an oxide of iron, often coating the grains and making a considerable percentage of the whole. The iron is usually present as ferric oxide. Calcareous sandstones are marked by the presence of carbonate of lime. When it exceeds the quartz in amount, the sandstone becomes a silicious limestone. In the argillaceous varieties, the binding material is a clay, or an impure kaolin.

The cementing material determines in most cases the color. The various shades of red and yellow depend upon the iron

oxides; some of the rich purple tints are said to be due to oxide of manganese.

The gray and blue tints are produced by iron in the form of ferrous silicate or carbonate. By an irregular association of masses of different colors a variegated surface is produced, or by an alternation of white and variously-colored laminæ a striped appearance is given to the mass.

Sandstones occur stratified and in beds of greater or less thickness, and they are said to be thick-bedded or thin-bedded. In some cases the beds are so thick, and the stone of such a uniform texture, that the stone can be worked equally well in all directions, and is known as *freestone*. A laminated structure is common, especially in the thin strata, or when the stone is micaceous. When the beds can be split into thin slabs along planes parallel to the bedding, it is called a *flagstone*. A less common structure is what is termed lenticular or wedge-shaped, in which the upper and under surfaces lack parallelism, and the beds wedge out. It makes the quarrying more difficult, and produces more waste material.

The variations in the nature of the component grains, and binding material, in their arrangement, and in the forms of bedding, produce a great variety of stone, and the gradations from one to another are slight. The hardness, strength, beauty and durability are determined by these varying elements of constitution. The stone best resisting the action of the atmospheric agencies is that in which the quartz grains are cemented by a silicious paste, or in which the close-grained mass approaches in texture a quartzite.

The presence of mineral liable to decomposition, as feldspar highly kaolinized, of mica, marcasite, and pyrite, of calcite in quantity, and clays, affects the durability and tends to its destruction.

Sandstones are classified according to their geologic age also. They are found occurring in all the series, from the oldest to the most recent formations. Those of a given age are generally

marked by characteristic properties, which serve for their identification, aside from the fossil organic remains by which their exact position in the geologic series is fixed. This persistence in characters is exemplified in the Medina sandstones, in the Devonian bluestone, and in those of Triassic age.

Sandstones occur in workable quantity in nearly all the greater divisions of the state.

Quarries have not, however, been opened everywhere in the sandstone formations, because of the abundant supply of superior stone from favorably situated localities. There are, in consequence, large sandstone areas and districts in which there is an absence of local development, or abandoned enterprises mark a change in conditions, which has injuriously affected the quarry industry.

Following the geologic order of arrangement and beginning with the Potsdam sandstone, the several sandstone formations are here briefly reviewed.

Potsdam sandstone

This formation is the oldest in which, in this state, sandstone is quarried for building purposes.[a]

The bottom beds are of fine, silicious conglomerate; above are sandstones generally in thin beds. It is gray-white, yellow, brown and red in color. In texture it varies from a strong, compact quartzite rock to a loosely coherent, coarse-granular mass, which crumbles at the touch.

Outcrops of limited area occur in the Mohawk valley. In the Champlain valley the formation is well developed at Fort Ann, Whitehall, Port Henry and Keeseville, and quarries are opened at these localities. The stone is a hard, quartzose rock, and in thin beds. North of the Adirondacks the formation stretches westward from Lake Champlain to the St Lawrence; and there are quarries in the towns of Malone, Bangor and Moira in Franklin county; in Potsdam and Hammond in St Lawrence county;

[a] Some of the sandstones east of the Hudson and in the Taghkanic range may belong to the Lower Cambrian. See *Amer. Jour. of Science*, series III, vol. 35, pp. 399-401. But there are no quarries opened in these localities.

and in Clayton, Jefferson county. In parts of Clinton county the stone is too friable for building.

The most extensive openings are near Potsdam; the stone is hard, compact and even-grained, and pink to red in color. Some of it has a laminated structure and striped appearance. It is an excellent building stone and is widely known and esteemed for its beauty and durability.

The Hammond quarries produce a gray to red stone. Nearly all of the output is cut into paving blocks and street material.

Hudson river sandstone

Rocks of this group outcrop in Orange county, northwest of the Highlands and in the valley of the Hudson river northward to the Champlain valley in Washington county. From the Hudson westward, the Mohawk valley is partly occupied by them. The belt increases thence in breadth, in a northwest course across Oneida, Oswego and Lewis counties, and continues to Lake Ontario.

The rocks consist of shales interbedded with sandstones and silicious conglomerates.

The sandstones are generally fine-grained and of light-gray or greenish-gray color. They are often argillaceous and not adapted for building purposes. But the even-bedded and well-marked jointed structure makes the quarrying comparatively easy, and the nearness to lines of transportation, and to the cities of the Hudson and Mohawk valleys have stimulated the opening of quarries at many points.

For common rubble work and for local use, the quarries in this formation have furnished a large amount of stone. The more important quarrying centers are now at Rhinecliff-on-the-Hudson, New Baltimore and Troy, in the Hudson valley; at Aqueduct, Schenectady and Duanesburg, Schenectady county; and Frankfort Hill, Oneida county. Flagstones are quarried from this formation in the gorge of the Bozenkill a few miles northwest of Altamont, Albany county.

PLATE CVI.—To face page 188.

J. N. Nevius, photo.

POTSDAM SANDSTONE, CLARKSON'S QUARRY, 3 MILES SOUTH OF POTSDAM, ST. LAWRENCE CO.

Oneida conglomerate

This formation is developed to its greatest thickness in the Shawangunk mountain in Orange and Ulster counties.

It is recognized in the Bellevale and Skunnemunk mountains, also, in Orange county. In the central part of the state it is traced westward in a narrow belt from Herkimer county into Oneida county. The prevailing rocks are gray and reddish-gray, silicious conglomerates and sandstones, which are noted for their hardness and durability. The cementing material is silicious. The jagged edges and angular blocks and the polished and grooved surfaces of the glaciated ledges, so common on the Shawangunk range, afford the best proof of the durable nature of these rocks. The bottom beds, near the slate, contain some pyrite. No attempt has been made to open quarries for stone, excepting at a few localities for occasional use in common wall work. The grit rock is quarried near Esopus creek for millstones, and at Ellenville is crushed for glass sand.

The accessibility of the outcrops to the New York, Lake Erie and Western railroad, the New York, Ontario and Western railroad, the West Shore railroad and the Delaware and Hudson canal lines is an advantage, as well as the comparative nearness to New York. No other formation in the state exhibits in its outcrops better evidence of ability to resist the weather.

Medina sandstone

The Medina sandstone is next above the Oneida conglomerate. It is recognized in the red and gray sandstones and the red and mottled (red and green) shales of the Shawangunk and Skunnemunk mountains in Orange county. A large amount of the red sandstone has been quarried on the north end of the Skunnemunk range, in the town of Cornwall, for bridge work on the railroads which cross the range near the quarry.

The red sandstone is seen exposed in the cuts of the Erie railway northeast of Port Jervis. This formation reappears in Oswego county, and thence west to the Niagara river in a belt bordering Lake Ontario.

Quartz is the principal mineral constituent associated with some kaolinized feldspar. The cementing material is mainly oxide of iron, with less carbonate of lime. The stone is even-bedded and the strata dip gently southward. The prevailing systems of vertical joints, generally at right angles to one another, divide the beds into blocks, facilitating the labor of quarrying.

Quarries have been opened at Fulton, Granby and Oswego, in Oswego county; at several points in Wayne county; at Rochester, on the Irondequoit creek, and at Brockport, Monroe county; at Holley, Hulburton, Hindsburg, Albion, Medina and Shelby Basin, in Orleans county; and at Lockport and Lewiston, in Niagara county. The Medina sandstone district proper is restricted to the group of quarries from Brockport west to Lockport.

The leading varieties of stone are known as the Medina red stone, the white or gray Medina and the variegated (red and white) or spotted. The quarries in this district are worked on an extensive scale, and their equipment is adequate to a large annual production. The aggregate output is larger and more valuable in dimension stone for dressing than that of any other quarry district in the state. Including the stone for street work, the total value is greater than that obtained from the stone of any other geological formation in the state. The stone has gained a well-deserved reputation for its value as a beautiful and durable building material; and its more general employment, both in construction and in paving, is much to be desired. The extent of the outcrops offers additional sites for quarrying operations, and the greater use of this stone, and the increase of the producing capacity of the district are here suggested.

Clinton group

The rocks of this group are shales, thin beds of limestone and shaly sandstones. They crop out in a narrow belt from Herkimer county west to the Niagara river and bordering the Medina sandstone on the south. Sandstone for building has been quarried in the southern part of Herkimer county; at Clinton, near Vernon

and at Higginsville in Oneida county, from this formation. The nearness of the Medina sandstone, with its more accessible quarries and superior stone, has prevented the more extensive development of the quarrying industry in the sandstone of the Clinton group.

Oriskany sandstone

The Oriskany sandstone formation is best developed in Oneida and Otsego counties. The rock is hard, silicious and cherty in places, and generally too friable to make a good building stone. No quarry of more than a local importance is known in it.

Cauda galli grit and Schoharie grit

These rocks are limited to Schoharie and Albany counties and to a very narrow belt which stretches south and thence southwest to Ulster county. The Cauda galli sandstones are argillaceous and calcareous and are not durable. They are used in Albany county for road metal, but are not very good for this purpose. The Schoharie grit is generally a fine-grained, calcareous sandrock which also is unsuited for building. Quarries in these rocks have local use only.

Marcellus shale

As its name implies, this formation is characterized by shaly rocks, which are not adapted to building. The abundance of good building stone in the next geologic member below it—the Corniferous limestone—whose outcrop borders it on the north throughout the central and western parts of the state, also prevents any use which might be made of its stone. A single quarry was at one time opened in it at Chapinville, Ontario county.

Hamilton group

The rocks of the Hamilton group outcrop in a narrow belt, which runs from the Delaware river, in a northeast course, across Sullivan and Ulster counties to the Hudson valley near Kingston; thence north, in the foot-hills, bordering the Catskills, to Albany county; then, bending to the northwest and west across the Helderberg mountains into Schoharie county; thence increas-

ing in width, through Otsego, Madison and Onondaga counties, forming the upper part of the Susquehanna and Chenango watersheds; thence west, across Cayuga, Seneca, Ontario, Livingston, Genesee and Erie counties to Lake Erie. In this distance there is some variation in composition and texture. In the western and central parts of the state there is an immense development of shales and the few quarries in the sandstone referable to this group are unimportant. In the Helderberg region in the Hudson valley and thence, southwest, to the Delaware river, the sandstones predominate, and all of the beds are more sandy than at the west.

Bluestone

There is a great development of the bluish-gray, hard, compact and even-bedded stone, which is known as 'Hudson river bluestone.'

This is a variety of sandstone, which, by reason of its even texture can be cut or sawed into any desired form and is therefore peculiarly available for house trimmings of various kinds. The sandstone is usually interbedded with shale and in general, the layers in the quarries vary from an inch to several feet in thickness; the thinner of these are used for flagstones and the thicker are cut into dimension stones for building purposes.

The geological horizon of the commercial bluestone is very near the dividing line between the Hamilton and Portage groups. It is, however, not usually possible to determine in which of these groups a given quarry belongs, owing to the great scarcity of fossils.

The bluestone industry is chiefly located in Ulster county and the quarries are almost innumerable but the business is controlled by a few large dealers who are located at points favorably situated for shipment and who, to a considerable extent, buy stone from the men who quarry it. Bluestone is also produced in the counties of Albany, Greene, Sullivan, Delaware and Chenango in Eastern New York and in Cattaraugus and Wyoming counties in Western New York.

The number of quarries is large and can be increased indefinitely, as nearly the whole area of the formation appears to be capable of producing stone for flagging or for building. The difficulty of indicating the division line between the Hamilton and the Oneonta and the Hamilton and the Portage groups of rocks makes it impossible to refer to localities more particularly. The quarries near Cooperstown, and in the lake region, particularly at Atwater, Trumansburg, Watkins and Penn Yan belong to the Hamilton group.

Portage group

In this is included the Oneonta sandstone, the limits of which at the east can not be indicated; the flagstone beds of the Hudson valley and of the eastern part of the State continue up into the Oneonta sandstone horizon. Many of the quarries are in the latter formation. The more western and northwestern and higher quarries are in it; and some of the Chenango county quarries also.

The Portage rocks in the western part of the State consist of shales at the base; then shales and flagstones; and the Portage sandstone at the top. In the last division, thick beds with little shale are marks of this horizon. The stone is generally fine-grained. The quarries near Portage and near Warsaw are in it; also the quarries at Laona and Westfield in Chautauqua county.

Although not of as great extent in its outcrop as the Hamilton group, the Portage rocks are developed to a thickness of several hundred feet along the Genesee river at Mount Morris and at Portage; and form a belt having a breadth of several miles through Tompkins, Schuyler, Yates, Ontario and Livingston counties, and thence west to Lake Erie. The formation is capable of supplying an immense amount of good building stone and flagstone throughout its undeveloped territory.

Chemung group

The rocks of the Chemung group crop out in the southern tier of counties, from Lake Erie eastward to the Susquehanna. The shales are in excess of the sandstones in many outcrops, and there

is less good building stone than in the Portage horizon. The variation in color and texture is necessarily great in the extensive area occupied by the Chemung rocks, but the sandstones can be described as thin bedded, generally intercalated with shaly strata, and of a light-gray color, often with a tinge of green or olive-colored. The outcropping ledges weather to a brownish color. Owing to the shaly nature of much of the sandstone of the Chemung group, the selection of stone demands care, and the location of quarries where good stone may be found is attended with the outlay of time and money, and with great chances of possible failure. Quarries have been opened near the towns and where there is a market for ordinary grades of common wall stone, and also for cut stone, but the larger part of their product is put into retaining walls. At Elmira and Corning good stone has been obtained, which is expensive to dress, and does not compete for fine work with sandstones from districts outside of the State. The quarries at Waverly, Owego, Elmira and Corning, and nearly all of the quarries in Allegany, Cattaraugus and Chautauqua counties are in the Chemung sandstone.

Catskill group

As implied in the name, this formation is developed in the Catskill mountain plateau in the eastern part of the state. Sandstones and silicious conglomerates predominate over the shales. The thicker beds of sandstones are generally marked by oblique lamination and cross-bedding, which make it difficult and expensive to work into dimension blocks. Except for flagging and for local use but little is quarried. There are no large towns in the district, and consequently the demand is light. There are, however, some good quarries, which are worked for flagging, chiefly along the New York, Ontario and Western railroad and the Ulster and Delaware railroad lines in Ulster and Delaware counties; and in the Catskills, in Greene county, there are quarries in Lexington, Jewett, Windham, Hunter and Prattsville.

Triassic formation

This formation, which is known, locally, as the red sandstone, is limited in New York to a triangular area in Rockland county, between Stony Point on the Hudson and the New Jersey line, and to a small outcrop near the north shore of Staten Island, which is the southern end of the same belt.

The sandstones are both shaly and silicious, and the varieties grade into one another. Conglomerates of variegated shades of color also occur, interbedded with the shales and sandstones. Formerly these conglomerates were in favor for the construction of furnace hearths. They are not now quarried. The prevailing color of the sandstone is dark-red to brown, whence the name 'brownstone.' In texture there is a wide variation, from fine conglomerates, in which the rounded grains are somewhat loosely aggregated, to the fine, shaly rock and the 'liver rock' of the quarrymen. Oxide of iron and some carbonate of lime are the cementing materials in these sandstones.

The well-known Massachusetts Longmeadow sandstone and the Connecticut brownstone are obtained from quarries in the Connecticut valley region, and of the same geological horizon. The Littlefalls, Belleville and Newark freestones are from the same formation in its southwest extension into New Jersey.

Quarries were opened in this sandstone more than a century ago, and many of the old houses of Rockland county are built of it. Prof. Mather reported 31 quarries on the bank of the Hudson near Nyack. The principal market was New York city, and the stone was sold for flagging, house trimmings and common walls. The Nyack quarries have been abandoned, with one or two exceptions, as the ground has become valuable for villa sites and town lots. There are small quarries at Suffern, near Congers Station, near New City and at the foot of the Torn mountain west of Haverstraw. They are worked irregularly and for local supplies of stone. The stone is sometimes known as 'Nyack stone,' also as 'Haverstraw stone.'

SLATE

Argillite, clay-slate, or roofing slate, which is marked by the presence of cleavage planes, and can be split into thin plates of uniform thickness, is a characteristic rock in the Hudson river group and the Lower Cambrian or Georgian group.

Slate suitable for roofing has been found in many localities, and quarries have been opened in Orange, Dutchess, Columbia, Rensselaer and Washington counties. The openings in Orange county have not resulted in productive quarries. In Columbia county quarries were worked many years ago, east of New Lebanon. The Hoosick quarries, in Rensselaer county, were once more extensively worked, and produced a good, black slate. Outcrops of red slate are noted east of the Hudson, from Fishkill and Matteawan northward, but no attempts have been made to open quarries in them.

The productive slate quarries of the state are in a narrow belt, which runs a north-northeast course through the towns of Salem, Hebron, Granville, Hampton and Whitehall in Washington county.

This slate belt is divided by the quarrymen into four parallel ranges or 'veins,' which are: East Whitehall red slates; the Mettowee, or North Bend red slate; the purple, green and variegated slates of Middle Granville; and the Granville red slates. The latter are close to the Vermont line. Further to the east, but over the state line, in Vermont, is the range of the sea-green slates.

The quarry localities are at Shushan, Salem, and Black Creek valley, in the town of Salem, Slateville, in Hebron, Granville, the Penrhyn Slate Company's quarries, Middle Granville, Mettowee or North Bend quarries, and the Hatch Hill quarries in East Whitehall.

LIMESTONE AND MARBLE

Limestones consist essentially of calcium carbonate. They are, however, often quite impure; and the more common accessory constituents are silica, clay, oxides of iron, magnesia, and bitumi-

nous matter. These foreign materials may enter into their composition to such an extent as to give character to the mass, and hence they are said to be silicious, argillaceous, ferruginous, magnesian, dolomitic, and bituminous.

The chemical composition is subject to great variation, and there is an almost endless series of gradation between these various kinds. Thus, the magnesium carbonate may vary in quantity from a trace, to the full percentage of a typical dolomite. Or, the silica may range from a fractional percentage to the extreme limit where the stone becomes a calcareous sandstone. Crystallized minerals, as mica, quartz, talc, serpentine and others, also occur, particularly in the more crystalline limestone.

In color there is a wide variation—from the white of the more nearly pure carbonate of lime through gray, blue, yellow, red, brown, and to black. The color is dependent upon the impurities.

The texture also varies greatly. All limestones exhibit a crystalline structure under the microscope, but to the unaided eye there are crystalline and massive varieties. There are coarse crystalline, fine crystalline, and sub-crystalline varieties, according as the crystals are larger, smaller, or recognized by the aid of a magnifying glass only. The terms coarse-grained and fine-grained may apply when there is a resemblance to sandstone in the granular state of aggregation. Other terms, as saccharoidal (like sugar), oolitic, when the mass resembles the roe of a fish; crinoidal, made up of the stems of fossil crinoids, also are in use, and are descriptive of texture. The state of aggregation of the constituent particles varies greatly, and the stone is hard and compact, almost like chert, or is loosely held together and crumbles on slight pressure, or again it is dull and earthy as in chalk.

The crystalline, granular limestones, which are susceptible of a fine polish, and which are adapted to decorative work, are classed as *marbles*. Inasmuch as the distinction is in part based upon the use, it is not sharply defined and scientific. Generally the term is restricted to those limestones in which the sediments have been altered and so metamorphosed as to have a more or

less crystalline texture. There is however some confusion in the use of the terms, and the same stone is occasionally known as marble and limestone, e. g., the Lockport limestone or marble; the limestone and coral shell marble of Becraft's mountain, near Hudson; the Lepanto marble or limestone near Plattsburg, and others.

The fossiliferous limestones are made up of the remains of organisms which have grown in situ, as for example, the coralline beds in the Helderberg and Niagara limestones, or have been deposited as marine sediments. In the case of the latter the fossils are more or less comminuted and held in a calcareous matrix. Generally the fossil portions of the mass are crystalline. The Onondaga gray limestone from near Syracuse, and the Lockport encrinal limestone are good examples.

The fossil remains are less prominent and scarcely visible in some of the common blue limestones, as in the lower beds of Calciferous and in some of the Helderberg series. These rocks are compact, homogeneous and apparently uncrystalline and unfossiliferous. They are usually more silicious or argillaceous, that is, they contain quartz or clay, the latter often in seams rudely parallel with the bedding planes. On weathering, the difference in composition is often markedly apparent at a glance. Similar differences in composition are seen in the more crystalline marbles, and are evident either by variation in color, or in the presence of foreign minerals, as mica, quartz, hornblende, pyrite, etc.

The variations in the strength and durability is as great as in the composition and texture. Some are stronger than many granites in their resistance to crushing force, and equally enduring; others consist of loosely cohering grains, and are friable and rapidly dissolved by atmospheric agencies. The more silicious and compact limestones are generally the more durable and stronger; in the marble the well-crystallized and more homogeneous texture consists with endurance and strength. Both the magnesian and dolomitic varieties are good stone as is proven by the Calciferous and the Niagara limestones, and in the marbles of Tuckahoe and Pleasantville, in Westchester county.

PLATE CVII.—To face page 198.

H. Ries, photo.

Marble Quarry, Tuckahoe, Westchester Co. Metamorphosed Calciferous-Trenton Limestone.

PLATE CVIII.—To face page 198.

J. N. Nevius, photo.

INTERIOR OF NORTHERN NEW YORK MARBLE CO.'S QUARRY, NEAR GOUVERNEUR, ST. LAWRENCE CO. PRECAMBRIAN.

Crystalline limestones occur in New York and Westchester counties, and in the Highlands of the Hudson. In the Adirondack region there are numerous localities. The rock in many of them is too impure and has too many foreign minerals to admit of its use as marble. Quarries have been opened in Westchester, Putnam and Dutchess counties, which have yielded a large amount of fine white marble. In the northern part of the state, the Port. Henry and the Gouverneur quarries have been productive. The geological horizon of some of these marbles is in doubt. The belt in the eastern part of Dutchess and Putnam counties belongs to the Vermont marble range, and is probably metamorphosed Trenton limestone. The Westchester marbles are of the same age.

The limestones which furnish building stone in this state are the Calciferous, Chazy, Birdseye, Black river, Trenton, Niagara, Lower Helderberg, Upper Helderberg, or Corniferous, and Tully. The geographical distribution is given in the following notes, and in the order of geological succession, from the lowest to the highest.

Calciferous sandrock

The rocks of the Calciferous formation in the Mohawk valley and in the Champlain valley are more silicious than at the southwest, in Orange county and in the Hudson valley, and hence the designation as a sandrock. Much of it at the north is a limestone rather than a sandstone, and may be termed a magnesian or silicio-magnesian limestone. Nearly all of the limestones, which are quarried for building stone, in Orange and Dutchess counties are from this formation. The stone occurs generally in thick and regular beds. It is hard, strong and durable and is adapted for heavy masonry as well as for fine cut work. The quarries near Warwick, Mapes' Corners and near Newburgh in Orange county and those on the Hudson river, near New Hamburg, are in the Calciferous. The Sandy Hill quarry and those at Canajoharie and Littlefalls are also in it.

Trenton limestone

Under this head the Chazy, Birdseye, Black river and Trenton limestones are included.

The Chazy limestone crops out in Essex and Clinton counties and in the Champlain valley—its typical localities. The beds are thick and generally uneven. Regular systems of joints help the quarrymen in getting out large blocks. Quarries at Willsboro Point and near Plattsburg are in the horizon of the Chazy. The stone is suitable for bridge work and for heavy masonry.

The members of the Trenton above the Chazy limestone are recognized in may outcrops in the southeastern part of the state; in the Hudson-Champlain valley; in the Mohawk valley; in the valley of the Black river and northwest, bordering Lake Ontario; and in a border zone on the north of the Adirondacks, in the St Lawrence valley. In a formation so widely-extended there is, as might be expected, some variation in bedding, texture and color. Much of the Trenton limestone formation proper is thin-bedded and shaly and unfit for building stone. In the Birdseye also the stone of many localities is disfigured on weathering, by its peculiar fossils. Generally the stone is sub-crystalline, hard and compact and of a high specific gravity and dark-blue to gray in color. But the variation is wide, as for example, between the black marble of Glens Falls and the gray, crystalline rock of the Prospect quarries near Trenton Falls. The variation is often great within the range of a comparatively few feet vertically; and the same quarry may yield two or more varieties of building stone. In several quarries the Birdseye and Trenton are both represented. Many quarries have been opened in the formation and there are many more localities where stone has been taken from outcropping ledges, which are not developed into quarries proper. The more important localities which are worked steadily are: Glens Falls, Amsterdam, Tribes Hill, Canajoharie, Palatine Bridge and Prospect in the valley of the Mohawk; and Lowville, Watertown, Three Mile Bay, Chaumont and Ogdensburg in the Black river and St Lawrence valleys. The railroad and canal lines, which traverse the territory occu-

pied by these formations, afford transportation facilities and offer inducements to those who are seeking new quarry sites where these limestones may be found in workable extent.

Niagara limestone

The Niagara limestone formation is well developed west from Rochester to the Niagara river; and there are large quarries in it at Rochester, at Lockport and at Niagara Falls. The gray, sub-crystalline stone in thick beds is quarried for building purposes. It is filled with encrinal and coralline fossils and the unequal weathering of the matrix and the fossiliferous portions are sometimes such as to give the dressed surface a pitted appearance with cavities which roughen and disfigure it. For foundations and heavy masonry it is well adapted. It has been extensively employed in the western part of the state.

Lower Helderberg limestones

The Water-lime, Tentaculite and Pentamerus limestones are included in this group. The outcrops are in the Rondout valley, southwest from Kingston to the Delaware river; in the foothills east of the Catskills—in Ulster and Greene counties; on Becraft's mountain, near Hudson; and in a belt stretching west from the Hudson valley, along the Helderbergs and across Schoharie into Herkimer county.

The Tentaculite limestone is dark-colored, compact and in thick beds and can be quarried in large blocks. Some of it can be polished and makes a beautiful black marble, as for example, that of Schoharie.

The Pentamerus limestones, both the lower and the upper, are in thick beds and are gray, sub-crystalline in texture, and look well when dressed. They are adapted to heavy masonry as well as for cut work.

Quarries are opened in this group of limestones in the Schoharie valley, at Howe's Cave, Cobleskill, Cherry Valley and in Springfield. The quarries west of Catskill and in Becraft's mountain, near Hudson, are also in it.

Upper Helderberg limestones

The Upper Helderberg formation appears in the Hudson valley at Kingston; thence it runs in a belt west of the river, to the Helderberg mountains, bending to the west-northwest, and thence west it continues across the state to the Niagara river and Lake Erie. The subdivisions are known as the Onondaga, the Corniferous and the Seneca limestones. The first is more generally recognized as the 'Onondaga gray limestone' and the last as the Seneca blue limestone.

There is much diversity in the limestones of this group in its long range of outcrop. The Onondaga gray stone is gray in color, coarse crystalline; and makes beautiful ashlar work, either as rock face or as fine tooled, decorative pieces.

The Corniferous limestone is hard and durable, but it is so full of chert that it can only be used for common wall work.

The Seneca blue limestone is easily dressed and is a fairly good building stone.

Limestone of the Upper Helderberg epoch is quarried extensively at Kingston, Ulster county, and is a valuable building stone. In Onondaga county there are the well-known Splitrock and Reservation groups of quarries, which have produced an immense quantity of excellent and beautiful stone and which has found a market in all of the central part of the state. They are in the lower member of the group. Going west, there are the large quarries in the Seneca limestone at Union Springs, Waterloo, Seneca Falls and Auburn. The LeRoy, Williamsville, Buffalo and Black Rock quarries are in the Corniferous limestone.

The aggregate output of the quarries in the Upper Helderberg limestones exceeds in value that of any other limestone formation in the state. The many quarries of the Trenton probably produce more stone.

Tully limestone

The Tully limestone lying above the Hamilton shales, is a thin formation which is seen in Onondaga county and to the west—

disappearing in Ontario county. It does not furnish any stone other than for rough work and in the immediate neighborhood of its outcrops.

Calcareous tufa

As a supplement to the limestones the quarries in calcareous tufa at Mohawk, in the Mohawk valley, and at Mumford, Monroe county, should here be mentioned, although they are only of local importance.

GLACIAL DRIFT

This material, consisting of unsorted clays, sands, gravels, cobbles and boulders, is found in all parts of the state. The nature of the imbedded stone varies greatly both as to variety and amount. In places the deposits are full of large blocks of stone and of more or less rounded and scratched boulders; in other localities the hard, quartzose cobbles and small boulders predominate. In the sandstone districts of the southern and western parts of the state the surface deposits of glacial drift contain much sandstone, as in the Medina sandstone belt, the Hudson river blue stone territory and the red sandstones at Haverstraw and Nyack. In the Highlands and in the Adirondacks the rounded, crystalline, granitoid and gneissic rocks predominate. On Long Island the terminal moraine includes a great amount of stone, and of many kinds.

The cobblestones were formerly used for paving roadways, but this kind of pavement is no longer laid. From the fact of the stone being picked off the fields in the clearing of land for tillage, the stone fragments from the drift have been known as 'field-stone;' and they were used in the earlier constructions for walls, foundations and buildings, in localities where no quarries had been opened.

Some of the oldest houses on the western end of Long Island, and in the Hudson river counties are built of such field stone. At Yonkers the excavations for foundations and in street grading afford an abundant supply of stone for common wall work. In parts of Brooklyn the drift furnishes a great deal of stone in the shape of huge boulders.

The stone of the drift is generally hard and durable, having resisted the wear of rough transportation. The economic use of the surface stones of the drift in constructive work, where they can be laid up in walls, is a desirable utilization of what is still in many parts of the state worse than waste—a nuisance in the tilling of the soil. This formation can not, however, be considered as one of the important sources of stone in the quarry industry, although capable of yielding a great deal of rough stone. It will no doubt do so in the future clearing and improvement of the country.

Road Metal

In New York the best materials for road metal are trap, granite and magnesian limestone.

Trap is a general term for some of the basic eruptive rocks, the word being related to or derived from the German *Treppen* which signifies a flight of steps and is suggested by the somewhat regular manner in which the rock is jointed.

The trap which is used in New York for a road metal is a diabase and consists chiefly of the minerals augite and labradorite, the former being a silicate of iron and magnesia and the latter being a lime-soda feldspar. Other minerals are present in small quantity but do not influence the properties which make the rock valuable as a road metal.

While sufficiently hard to resist the wear of heavy traffic to a satisfactory extent, it possesses a high degree of binding or cementation power. This means that the dust produced by wear when moistened unites quite firmly and forms a cement which binds the larger fragments to a considerable extent.

This property is most noticeable in rocks containing much lime, magnesia and alumina.

Good trap is found only in Richmond and Rockland counties, and in the intermediate area of New Jersey bordering the Hudson river. Its outcrop is known as the 'Palisades.'

Granite consists chiefly of quartz mixed with one or more of the feldspars and hornblende or a mica. Hornblende has essentially

the same composition as augite which occurs in trap; and a hornblende granite should be a very good road metal. Where hornblende is absent one would expect to find less binding power.

Granite is harder than trap and therefore should resist wear better, but this quality is offset by its usually smaller binding power so that trap should be preferred as a rule.

Granite is found in the Adirondack region and in the Highlands of the Hudson, also in Westchester county. The commercial term granite includes various kinds of gneiss.

Magnesian limestone has great binding power but is quite soft and therefore not very durable for heavy traffic. Chemically, this rock is a carbonate of lime, containing also magnesia, alumina and silica. It has been suggested that it might be used profitably as a binder with stone of less binding power.

Sandstone has usually no lime, magnesia or alumina and therefore has no binding properties and never makes a first rate road, as the fragments continually break loose.

Limestone is found chiefly in areas parallel to and near the main line of the New York Central railroad and in a zone around the Adirondacks.

In New York the best road materials occur in certain limited areas, and at points distant from these the cost of transportation is the controlling feature.

For high class road building, trap and granite will be preferred and used in all places where their cost is not prohibitory. Experience shows, however, that unless these materials are used under the direction of experienced road engineers, they are less satisfactory than limestone, and when it is proposed to macadamize a road by simply covering it with broken stone, the latter though less durable, will be more satisfactory.

When granite and trap are properly laid, on a well prepared bed and rolled with a heavy steam roller to the proper standard of firmness, nothing can be better, but where no steam roller is available and the subgrade is not properly prepared, the trap and granite are liable to afford only an unpleasant and uneven surface of hard angular fragments which ceaselessly roll about on the

surface of the road injuring the horses and making pleasure driving impossible.

Limestone from its softness and greater binding power is more easily rolled into an even surface under the wheels of vehicles, and while not having the durability to support heavy traffic for a long time, can be cheaply renewed if the source of supply is not far distant. This fact has been recognized for a long time at points within easy reach of the limestone quarries. In Onondaga county at many points a portable crusher has been used to crush the blocks for road metal from the limestone fences which are cheerfully donated by the residents for the improvement of the roads. There are many other counties in which this might be done as may be seen from the geologic map. In most of these areas limestone will be found in the fences and may be crushed for road metal at small expense.

Many of the local stone quarries, which are scattered over the state, sell for road metal the rock obtained in stripping off the upper layers from their quarries.

A few large quarries are operated for road metal alone and deserve special mention.

Many tons of material are quarried annually from the Palisades range near Piermont. The material, which is exceedingly tough, is either dressed for paving blocks or crushed for road metal.

Farther up the Hudson river the limestone quarries of Tomkins Cove have been in operation for a number of years and supply large quantities of rock for macadam. Other quarries are at South Bethlehem, Albany county, Howe's Cave, Schoharie county and there are several near Syracuse and Buffalo. This magnesian limestone is one of the best materials used. It is hard, packs easily and makes a good surface, but the cost of maintenance is considerable.

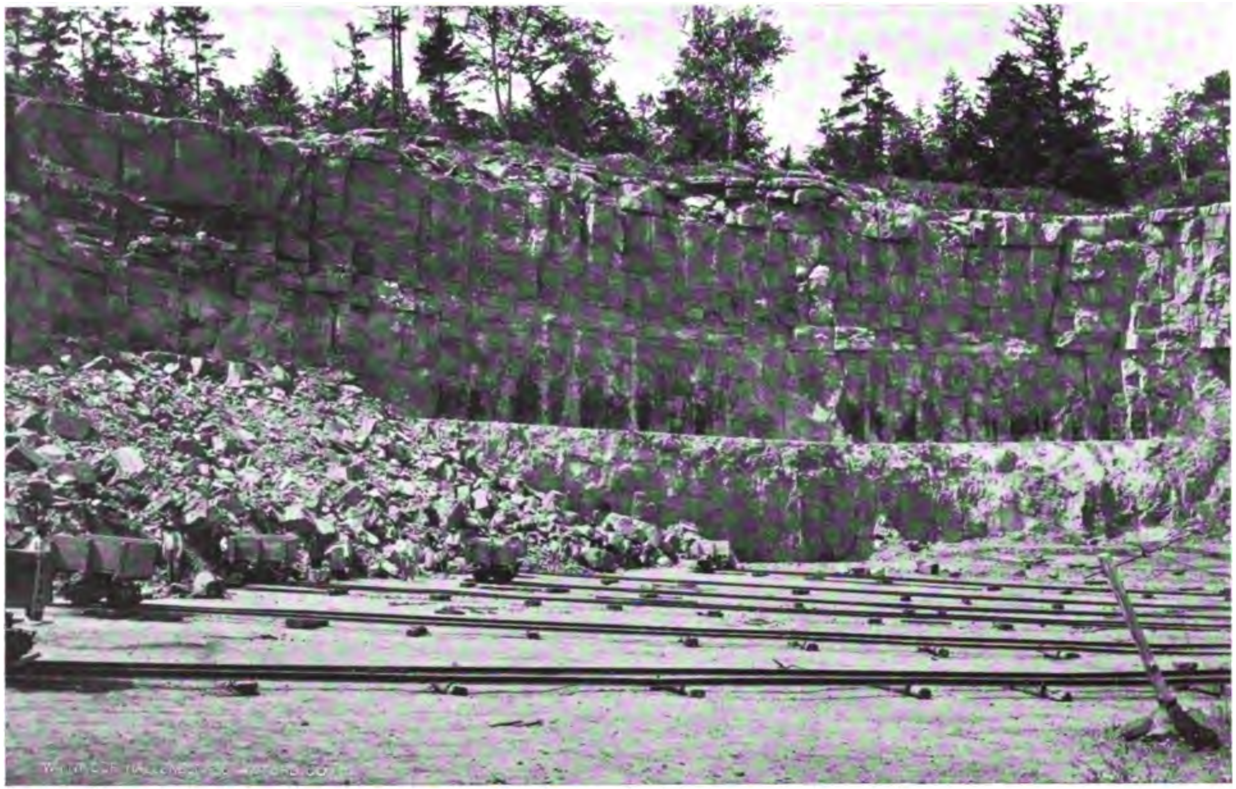
At Iona Island a granite is quarried and crushed to five or six different sizes for road metal and concrete. The fine residue or dust is sold for polishing.

PLATE CIX.—To face page 206.

H. Ries, photo.

LIMESTONE QUARRY, TOMKINS COVE, ROCKLAND CO. METAMORPHOSED CALCIFEROUS-TRENTON LIMESTONE.

PLATE CX.—To face page 206.



H. Ries, photo.

QUARRY IN LOWER HELDERBERG LIMESTONE, SOUTH BETHLEHEM, ALBANY CO.

PLATE CXI.—To face page 206.

I. P. Bishop, photo.

ROAD METAL AND PAVING BLOCK QUARRY OF THE BARBER ASPHALT CO., NEAR HUMBOLDT PARKWAY, BUFFALO, ERIE CO.
CORNIFEROUS LIMESTONE.

PLATE CXII.—To face page 206.

I. P. Bishop, photo.

STONE CRUSHING PLANT OF THE BARBER ASPHALT CO., BUFFALO, ERIE CO.

The Hudson River Stone Supply Company has an extensive plant for quarrying and crushing granite, at Breakneck Mt, north of Cold Spring. The same company operates a second plant for supplying crushed limestone at Stoneco, north of New Hamburg.

One of the largest quarries in the state is that of P. Callanan at South Bethlehem, Albany county. The Lower Helderberg limestone is the rock used and it makes a good road.

The Cauda galli grit of Albany county is used in small quantities locally and makes an excellent road, though it is not durable.

At Duanesburg, near Schenectady, sandstone of the Hudson river group is crushed for road metal.

At Port Chester, Westchester county, a coarse-grained granite is quarried and is considerably used locally, but the best macadam roads of that district are of limestone from Tomkins Cove.

The gray gneiss has been considerably used as a road material in Westchester county.

On Staten Island the yellow gravel is much used for road making; also the diabase or trap from the Graniteville quarries, which is being extensively used on a system of county roads with the most satisfactory results.

The materials used for making roads in the state vary with the locality. If the traffic on the road is moderate it is generally safe to use the local material, whatever its nature, unless it be shale, but if there is a heavy traffic it will pay in most instances to get a stone of superior quality from elsewhere.

The requisite qualities of a road metal are hardness and toughness. Where both these qualities are not obtainable in the same stone the latter is perhaps preferable.

Silicious rocks, though often hard, do not consolidate as well nor so quickly as limestone, owing to the sandy detritus formed by the former having no cohesion. The detritus of magnesian limestone acts like a mortar.

Granite and gneiss, especially if very micaceous, are apt to disintegrate rapidly and produce dust and mud.

Shale is to be avoided, as it breaks up rapidly, forming a sticky mud.

Gravel, while making a serviceable road, does not pack well, and is not durable. If it has to be used, some of the difficulty may be overcome by cracking the pebbles so as to produce an angular form.

Clay and Clay Products[a]

Deposits of clay occur in nearly every county of New York. They belong to three geological periods, namely:

Quaternary, Tertiary and Cretaceous.

The clays of the first age are by far the most common. Those of the second are somewhat indefinite in extent, but they probably include a large number of the Long Island deposits. Of the third class there are undoubted representatives on Long Island and Staten Island.

The clays of the mainland are all Quaternary so far as known. The problems of Quaternary geology in New York are by no means solved, and it is not always possible to decide on the causes leading to the deposition of any particular body of clay by a single visit to the locality.

A great majority of the deposits are local, lying in the bottoms of valleys which are often broad and fertile. They vary in depth from four to 20 or even 50 feet; as a rule they are underlaid by modified drift or by bed rock. The clay is generally of a blue color, the upper few feet being weathered mostly to red or yellow. Stratification is rarely present, but streaks of marl are common. In some of the beds small pebbles, usually of limestone, are found, and these have to be separated by special machinery in the process of manufacture. In many instances the clay is covered by a foot or more of peat.

These basin deposits are no doubt the sites of former ponds or lakes, formed in many instances by the damming up of valleys, which have been filled later with the sediment of the streams from the retreating ice sheet. The valleys in which

[a] Abridged from Bulletin No. 12 New York State Museum, by Heinrich Ries.

these deposits lie are usually broad and shallow. The broad flat valley in which the Genesee river flows from Mt Morris to Rochester is a good example. The waters of the river were backed up by the ice for a time, during which the valley was converted into a shallow lake in which a large amount of aluminous mud was deposited. This material has been employed for common brick.

Around Buffalo is an extensive series of flats underlaid by a red clay. A thin layer of sand suitable for tempering overlies the clay in spots, and limestone pebbles are scattered through it. Similar deposits occur at several localities to the north of the Ridge road and around Niagara Falls, also at Tonawanda and La Salle, to the north of Buffalo, as well as south of it along the shore of Lake Erie. No doubt much of this clay was deposited during the former extension of the Great Lakes.

Prof. James Hall mentions deposits of clay at the following localities: at Linden, one mile south of Yates Center; [a]along the shore of Lake Ontario, east of Lewiston; on Cashaqua creek [b]deposits of tenacious clay due to the crumbling of the argillaceous green shales; in Niagara county [c]beds of clay are said to occur in every town, but they often contain a considerable amount of lime.

At Levant, four miles east of Jamestown, Chautauqua county, is an interesting bed of blue clay having an area of several acres. It is probably of post-glacial age.

At Breesport, near Elmira, is a bank of blue clay rising from the valley to a height of 50 feet. It was evidently formed when the valley was dammed up, and has subsequently been much eroded so that all that now remains is a narrow terrace along the side of the valley. A similar deposit is found at Newfield, south of Ithaca. A moraine crosses the valley a mile or two south of it.

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[a] Geology of New York, 4th District, 1843, p. 437.
[b] Ibid., p. 227.
[c] Ibid., p. 444.

In the southern portion of the state we find clays in abundance, in all the valleys, and lowlands. The extensive marshes near Randolph and Conewango are said to be underlaid by clay throughout their entire extent.

A bed of blue and red clay is being worked at Brighton near Rochester. This deposit lies near the head of Irondequoit bay.

Clays are also found at several points in the valley of the Oswego river from Syracuse to Oswego, an important one being at Three Rivers.

Deposits of clay suitable for brick and tile occur extensively in the lowlands bordering the Mohawk river from Rome to Schenectady. The beds vary in thickness from six to 15 feet and are mostly of a red, blue or gray color.

An extensive bed of red and gray clay, 20 acres in extent and horizontally stratified, occurs at Watertown. The deposit is 20 feet thick and rests on Trenton limestone.

Another deposit of considerable size is being worked at Ogdensburg. The clay is blue and has a depth of 60 feet.

HUDSON VALLEY

Among the most extensive and important clay formations occurring in New York are those of the Hudson valley. These deposits indicate a period of depression, and deposition in quiet water. The clay is chiefly blue, but where the overlying sand is wanting or is of slight thickness, it is weathered to yellow, this weathering often extending to a depth of 15 feet below the surface, and to a still greater depth along the line of fissures. The depth of oxidation is of course influenced by the nature of the clay; the upper portion weathering easily on account of its more sandy nature and hence looser texture. Horizontal stratification is usually present, and the layers of clay are separated by extremely thin laminæ of sand. At some localities the layers of the clay are very thin and alternate with equally thin layers of sandy clay. This condition is found at Haverstraw, Croton, Dutchess Junction, Stony Point, Fishkill, Cornwall, New Windsor, Catskill and Port Ewen. At all of the above-mentioned localities except

PLATE CXIII.—To face page 210.

H. Ries, photo.

PLEISTOCENE BRICK CLAYS, HAVERSTRAW, ROCKLAND CO.

the last two, the clay is overlaid by the delta deposits of rivers tributary to the Hudson, and the alternation of layers may be due to variations in the flow of the rivers emptying at those points, the sandy layers being deposited during periods of floods. Isolated ice-scratched bowlders are not uncommonly found in the clay.

There is often a sharp line of division between the yellow weathered portion and the blue or unweathered part of the clay. The line of separation between the clay and overlying sand is also quite distinct in most cases. Of the blue and the yellow clay the former is the more plastic, but both effervesce readily with acid, due to the presence of 3 to 6% of carbonate of lime, and are, therefore, properly speaking, marly clays. The clay is underlaid by a bed of gravel, sand, hardpan, bowlder, till or bed rock. From Albany to Catskill the underlying material is a dark gray or black sand with pebbles of shale and quartz. The sand grains are chiefly of pulverized shale, the rest being silicious and calcareous with a few grains of feldspar and garnet. This sand can often be used for tempering, but at Catskill contains too much lime for this purpose.

From Catskill northward the clay is in most cases covered by but a foot or two of loam. South of Catskill the character of the overlying material varies.

THE CLAYS OF THE CHAMPLAIN VALLEY

The clays of the Champlain valley are estuary formations and of the same age as the Hudson river clays. They underlie terraces along the lake which have been elevated to a height of 400 feet above the lake surface. These terraces may be traced almost continuously from Whitehall, at the head of Lake Champlain, to the northern end of the lake and beyond it, but on account of the extensive erosion which has taken place, they are usually narrow, and it is only at sheltered points, like Port Kent and Beauport, that they are especially prominent. The section involved is yellowish brown sand, yellowish brown clay and stiff blue clay, the latter being rather calcareous. The upper clay is somewhat

silicious, and its coloring is due to the weathering of the lower layer. This formation has a thickness of about 15 feet, but sometimes, as at Burlington, it reaches a thickness of 100 feet. Isolated bowlders are occasionally found in the clays. The clays are usually horizontally stratified, and contortions of the layers are extremely rare. Numerous marine Quaternary fossils have been found in the overlying sands; the skeleton of a whale has also been found in them.

Openings have been made in these deposits for the purpose of obtaining brick clays at Plattsburg and a few other localities.

LONG ISLAND CLAYS

Clay beds are exposed along the north shore of the island and at several points along the main line of the Long Island railroad.

There is still some doubt as to the exact conditions under which the beds of clay and gravel which form the greater portion of Long Island were deposited, but it is probable that the clays represent shallow water marine deposits of Cretaceous and Tertiary age.

The age of the clays is still largely a matter of speculation, and will probably remain so in many cases unless palaeontologic evidence is forthcoming. Those on Gardiner's Island are quite recent, as shown by the contained fossils, and the clay on Little Neck, near Northport, is Cretaceous. The age of the Glen Cove clay is probably Cretaceous.

Cretaceous leaves in fragments of ferruginous sandstone have been found along the north shore of Long Island from Great Neck to Montauk Point,[a] but they are usually much worn and scratched and have evidently been transported from some distant source. The clays at Center Island, West Neck, Fresh Pond and Fisher Island are very similar and are very probably of the same age, possibly Tertiary, but we lack palaeontologic or stratigraphic evidence. At West Neck the clay underlies the *yellow gravel,* and the latter is covered by the drift, so that is Prepleistocene.

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a Hollick, *Notes on Geology of the North Shore of Long Island*, Trans. N. Y. Acad. Sci., XIII.

STATEN ISLAND CLAYS

The clays of Staten Island are chiefly Cretaceous, as proven by the fossils found in them. The chief outcrops are at Kreischerville, Green Ridge and Arrochar. Besides the clay there are several 'kaolin' deposits.

These clays are used in the manufacture of drain tile, terra cotta, etc.

CLAY PRODUCTS

The increasing value of clay for the manufacture of brick, tile, terra cotta, pottery, etc., and the ever growing demand for these products have given rise to an industry which is rapidly assuming vast proportions, and will, in the near future, become one of the most extensive and important in the country. Scattered over New York are extensive deposits of clay, many of them capable of being used for the manufacture of terra cotta, roofing tile and the coarser grades of pottery. To add to their value the most extensive beds of clay are situated in close proximity to the waterways and railroads which lead to the principal cities of the state. The commoner kinds of clay products, such as building brick, are marketed within the state, but the higher grades, such as terra cotta and roofing tile, have found good markets outside of New York.

At present bricks are the chief source of income. That the other branches of the clay industry are not further advanced is probably due in a large measure to the fact that the clay deposits of the state have been so little exploited or otherwise examined. Though many of the deposits have been opened up and are still being worked, there are numerous others scattered over the state which are still untouched. Few of the clays are found to be of sufficiently refractory character to be used for making fire brick, gas retorts, or other products which in use are subjected to a higher degree of heat; but for the manufacture of coarse pottery, terra cotta, paving brick, etc., many of the clays are eminently suited.

Shales and Shale Products

Within the last seven or eight years the manufacturers in New York have turned their attention toward the extensive beds of argillaceous shale which the state contains, and which on trial have given very satisfactory results. Several large firms are using them for the manufacture of sewer pipe, terra cotta, paving brick and roofing tile. The shale formations at present used are the Salina, Hamilton and Chemung. The Hudson river shales are no doubt sufficiently argillaceous over many areas to be used for the manufacture of clay products, and the same may be said of the Niagara shale, which weathers to a clay.

Iron Ores

The iron ores of New York have been carefully studied and described by Prof. J. C. Smock, who has published his results in Bulletin No. 7[a] of the New York State Museum and by Mr. Bayard F. Putnam, who contributed an article on this subject to the volume on Mining Industries (No. XV) in the report of the tenth census. These two important papers, taken together give a most complete review of the sources of iron in New York. Our knowledge of the Adirondack ores is supplemented by the work of Prof. J. F. Kemp, which is contained in Bulletin No. 13 of the New York State Museum, entitled the Geology of Moriah and Westport townships. The localities of all the principal mines are shown on the economic map.

Iron in its native or metallic form is not known to exist within the state of New York, nor is it at present anywhere a commercial source of the metal. We are therefore chiefly dependent upon the combinations of iron with oxygen for our supply of that indispensable substance.

The ores of iron, which occur in beds and deposits of workable size in the state of New York, may be classified by their chemical composition, into oxides and carbonates of iron, and these may be subdivided, following the mineralogical characters, into

[a] The following description is abridged with some alterations and additions from Bulletin No. 7.

species and varieties. The following tabular arrangement shows the natural grouping of the species:

	Chemical name	Mineralogical species and common names
Oxides	Ferric and ferrous oxides. Proto-sesquioxide of iron. 72.4 % of iron.	Magnetite. Magnetic iron ore. Titaniferous iron ore.
	Anhydrous ferric oxide. Sesquioxide of iron. 70 % of iron.	Hematite. Red hematite. Specular ore. Clinton ore.—Fossil ore. Red ochre.
	Hydrated ferric oxide. Sesquioxide of iron. 60 % of iron.	Limonite. Brown hematite. Brown ochre. Bog iron ore.
Carbonates	Ferrous carbonate. Carbonate of iron. 48 % of iron.	Siderite. Carbonate ore. Spathic Iron ore Clay iron stone. 'White Horse.'

A general law of occurrence of iron ores is that certain species occur in, or are characteristic of, definite geological horizons. For example, the magnetic iron ores and the red hematite are found in the crystalline rock areas of the Pre-cambrian; the fossil ore, the limonite or brown hematite and the carbonate are found in the Palaeozoic rocks; and the bog iron ore in the more recent formations of Tertiary and Post Tertiary ages. There are, as might be expected, many exceptions; but in the greater number of these apparently exceptional cases, the surface alteration, due to weathering or other atmospheric agencies, explains the occurrence.

This relation between the geological formation and the mineralogical species or *kinds* of iron ore indicates the areas in which they may occur, and determines roughly their limits. Hence, a geological map of the state shows approximately correct boundaries of the several iron-ore districts, and is, as it were, an iron

mines map. The geology of a county or district gives the clue in searching for ore; and its importance can not be too strongly stated, both as a guide, suggesting exploration, and warning against unnecessary and fruitless surveys and wasteful outlays of time and money. For example, the magnetites belong to the crystalline rock districts, and the search for them in the later, sedimentary rocks of the adjacent territory would be a hopeless task; or, again, the exploration of the Highlands or Adirondacks, for carbonate ores, would be equally unscientific and destitute of good results.

The geological formations, which are characterized as definite ore horizons, become the basis of a natural arrangement of the ore districts of the state. They are well marked geographically also.

Following this geologico-geographical arrangement, the groups and iron-ore districts are:

1 The Highlands of the Hudson.—Magnetic iron ores.

2 The Adirondack region, including the lake Champlain mines.—Magnetic iron ores.

3 The hematites of Jefferson and St Lawrence counties.

4 The Clinton or fossil ores.

5 The limonites of Dutchess and Columbia counties.

6 The limonites of Staten Island.

7 The carbonate ores of the Hudson river.

A few isolated mines can not be thus classified, as the hematite near Canterbury, Orange county, Ackerman's mine near Unionville, Westchester county, the Napanoch and Wawarsing mines, in Ulster county, the hematite of Mt Defiance in Ticonderoga, and the bog iron ores which are scattered in all of the great divisions of the state. The iron sands of the shores of Long Island are left out, as not properly a natural source of iron.

MAGNETIC IRON ORES

The Highlands of the Hudson

Magnetite is one of the common minerals in the crystalline rock region of the Highlands. It occurs as an accessory constituent in the granitic and gneissic strata; and by itself, forms

beds of considerable extent and thickness. Accordingly as it is more or less free from foreign minerals it is rich or lean, varying from the pure magnetic iron ore which contains 72.4% of iron to rock containing only traces of iron in its mineralogical composition. The beds of ore show lamination and are faulted, folded and contorted as the inclosing strata of rock, and have the same general strike and dip in common with the latter. They are generally of irregular form, in places widening into thick deposits or lenticular shaped masses, in others contracted in thin sheets, which are not mined profitably. The ore is found in some cases to separate into thin layers, and masses of rock ('horses') are met with entirely surrounded by the ore. The phases of variation are almost as many as there are mines, where they can be studied. In the larger and older mines the ore has been followed for thousands of feet in the line of strike or on the course of the ore, and for hundreds of feet in depth (on the line of dip) without reaching its limits. Owing to the unprofitable nature of working such thin ore beds, they are often not followed to the end, and the real extent of few of these ore deposits is known. In general, it may be stated that in this region the ore beds stand nearly on edge and have a northeast and southwest strike and a descent or dip at a steep angle to the southeast. In consequence of their highly inclined position and their irregular shape these ore bodies are called 'veins,' less frequently 'chimneys' and 'shoots' of ore.

The magnetic iron ore has not been found distributed uniformly throughout the Highlands. There appear to be certain ore *ranges* or belts in which the larger and more productive mines are opened. There are mine groups also, as the Sterling Iron and Railway Company's mines, the Greenwood mines, in Orange county; the Todd-Croft and Sunk mines, and the Croton-Brewster ranges in Putnam county. The boundaries of these ore-bearing belts and the intermediate barren territory have not been determined, since the exploration has been largely made by individual effort and without any general plan covering the whole area.

Mines have been opened in Orange, Rockland, Westchester

and Putnam counties in this iron ore district and from the New Jersey line at the southwest to the Connecticut boundary on the east. Some of the largest and most productive mines in Orange county have been worked more than a century.[a] This county was famous for its iron manufacture during the revolutionary war.[b] The greatest development of the iron mines in Putnam county has been since the opening of the Tilly Foster and Mahopac mines or during the last 25 years. The distance from public lines of transportation, the increased cost of working the smaller 'veins' at greater depths, the low prices for iron ore and the competition with the richer ores of other parts of our country have necessitated the suspension of work in some of the mines and led to the permanent abandonment of those most unfavorably situated. The ores of the Highlands district are the hard, crystalline magnetites. They are generally rich, free from titanium, but contain a slight excess of phosphorus above the limit for the manufacture of Bessemer iron, excepting the Mahopac and Tilly Foster mines, which have yielded a large amount of Bessemer ore, and a few small mines, but which are no longer worked.

The Adirondack Region, Including the Lake Champlain Mines

The Adirondack region, the great mountain plateau of northern New York, is bounded by the valleys of Lake Champlain on the east, of the St Lawrence river on the north and northwest, of Black river on the west, and the Mohawk on the south.

Magnetite is one of the common minerals in the Adirondacks, and is widely distributed, both as a constituent or accessory mineral in rocks, and in beds of workable extent. Mines have been opened in all parts of the region, but the greatest development has been in the valley of Lake Champlain, and hence the ores are known in the market as Lake Champlain ores.

The beginnings of iron-ore mining in the Lake Champlain valley were early in the present century. Some of the forges were

[a] Ore was discovered on the Sterling tract as early as 1750; the Forest of Dean mine was opened about the same time.

[b] See *History of the Manufacture of Iron in all Ages*, by James M. Swank, Philadelphia, 1884, pp. 102-106.

in operation in 1801 and 1802, and they were run upon the ores in their vicinity. But the output was small, in the aggregate a few thousands of tons. The rapid increase was after 1840.

THE HEMATITE ORES OF ST LAWRENCE AND JEFFERSON COUNTIES

The hematites, or red hematites, as distinguished from the brown hematites (limonites) are mined in a narrow belt, scarcely 30 miles long, stretching from Philadelphia, in Jefferson county, northeast into Hermon, in St Lawrence county. The ore deposits are found associated with a so-called *serpentine* rock, and lying between the Potsdam sandstone and the crystalline rocks of the Archaean age.

The hematite of these mines is generally firm and massive, of a deep red color, soiling whatever it touches. In some of the mines there is a specular ore, which has a crystalline structure, metallic lustre and is of a steel-gray to black color. Calcite, carbonate of iron, ferruginous quartz, pyrite and millerite occur in the ore. These ores average from 48 to 53% of metallic iron. They contain an excess of phosphorus above the limit demanded by furnace managers for making Bessemer iron. For mixing with more refractory ores they are sought after, being almost self-fluxing. In the market they are often known as 'Antwerp red hematites' and 'Rossie hematites.'

Charcoal furnaces were built early in this century at Rossie, St Lawrence county, and at Sterlingville and Antwerp, in Jefferson county, for smelting these ores.

THE CLINTON OR FOSSIL ORES

The red hematite of the Clinton group bears several names; from its aggregated grains it is termed 'oolitic ore' or 'lenticular iron ore;' from its fossiliferous character, it is widely known as 'fossil ore,' and from its place in the geological series, it is often called 'Clinton ore.' It is remarkable for the thin, yet persistent beds over wide areas, which lie between green shales and calcareous strata. Following the outcrop of the Clinton group, the ore has been found in Herkimer, Oneida, Madison,

Cayuga, Wayne, and Monroe counties. West of the Genesee river Prof. Hall reports that it was not seen.[a] There are two beds, generally about 20 feet apart, according to Vanuxem's report on the Clinton group, thin, averaging little more than a foot, and distinguished by more abundant oolitic particles in the lower bed and by the larger grains and concretions in the upper bed.[b] Very little mining has been done, excepting in the towns of Clinton, Oneida county, and Ontario, in Wayne county. The average thickness of the beds in these mines is 30 inches, and one bed only is worked. They lie almost horizontal, dipping slightly to the south; and in the extraction of the ore a part of the overlying shales has to be removed and the roof supported by timbering.

The ore consists of lenticular-shaped grains, closely aggregated in a firm solid mass, which has to be broken up by blasting and heavy sledging. It is more friable and soft on the outcrop. It is brownish red in color and soils like a paint. The percentage of metallic iron varies less than in the magnetic iron ores and in the brown hematites. The average is 44 to 48%. The phosphorus is above the Bessemer limit. It is well adapted for making foundry iron and is used for that class of iron mainly. Local furnaces take nearly all the output of the mines. The first lease for digging Clinton ore was given in 1797.[c]

THE LIMONITES OF DUTCHESS AND COLUMBIA COUNTIES

The ore deposits and mines, as here grouped, are in two principal ranges and limestone valleys. First, the Fishkill-Clove belt, stretching northeast, from the Highlands of the Hudson, across the towns of Fishkill, East Fishkill, Beekman and Unionvale; second, the north-south valley, traversed by the New York and Harlem railway, from the Highlands across Dutchess county, and to Hillsdale in Columbia county. The limonite, or brown hematite ore, is found in small pockets of irregular shape, and

[a] Hall Report on *Survey of the Fourth Geological District*, Albany, 1843, p. 61.
[b] Vanuxem Report on *Survey of the Third Geological District*, Albany, 1842, p. 83.
[c] Birkinbine; *The iron ores east of the Mississippi River*, in Mineral Resources of the United States for the calendar year 1886, p. 50.

also in large deposits, which are associated with ochreous clays, and in some cases, with a gray carbonate of iron, in beds underlying it. These ore bodies are wholly in the limestone or between the limestone and the adjacent slate or schist formations, or they are in the latter, and as a rule of occurrence they are found on or near the dividing line between these formations. Near Fishkill and at Shenandoah the deposits are at the border of the Cambrian sandstone and at the foot of the Archaean ridges. The existence of the carbonate ore in the deeper parts of some of the mines and interstratified with the limestones is suggestive of the origin of the oxide (limonite) by the decomposition of the ferriferous beds through oxidation and the agency of carbonated waters, and of the great masses of colored clays, also, through the disintegration and decay of the slaty rocks and more argillaceous limestone. The limestone of these valleys and the overlying slaty rocks have been studied by Prof. Dana, and are referred by him to the Trenton limestone and the Hudson river slate formations.

The ore occurs, (1) in large masses, somewhat cellular, having the interstices filled with clays or sandy earths, (2) in cavernous and hollow 'bombs' often with beautiful mammillary or stalactitic incrustations on the interior, and, (3) in irregularly shaped, fragmentary masses, distributed unevenly through the ochreous clays ('ochres') and sandy earths.

The earliest iron manufacture in the state was in Columbia county, on Ancram creek, and was probably on these ores.

THE LIMONITES OF STATEN ISLAND

The group of iron mines on Staten Island is in a superficial deposit probably derived from the underlying rock in the process of decomposition which has produced the serpentine of that region.

THE CARBONATE ORES OF THE HUDSON RIVER

The mines of spathic iron ore, or carbonate ore, are in the valley of the Hudson river, in Columbia county, south of the city of Hudson, and in Ulster county near Napanoch. The mines

south of Hudson are known as the Burden iron mines; and, on account of their extent and productiveness, and the comparative insignificance of the Ulster county mines, they may be considered as practically the whole of this group. The range in which the Burden mines are opened is between one and two and a-half miles east of the river, opposite Catskill, and is four miles in length, from north to south. It lies partly in the town of Greenport and partly in Livingston. The ore crops out in the western face and near the crest of Plass Hill at the north, and in Cedar Hill and Mount Thomas at the south. It is stratified, and its bed dips at angles of 20° to 40° to the east.

The first mining of considerable extent done on this range was in 1874.

LIME AND CEMENT.

Lime is produced throughout the State on the outcrops of the Calciferous, Trenton, Niagara and Helderberg limestones. Some of the chief localities are Glens Falls, Howe's Cave, Rochester, Buffalo, Sing Sing, Pleasantville and Tuckahoe. Hydraulic cement or water lime is chiefly produced from beds of hydraulic limestone in the Water lime group at the base of the Lower Helderberg. Rondout and Rosendale, Howe's Cave and the vicinity of Syracuse are important commercially for this product. At Akron and Buffalo much water lime is made, but from a lower formation, probably the Salina Group.

Portland cement is made from marl and clay at Warner's near Syracuse, and at Wayland, Steuben county; from lime and clay near Glens Falls and at other points.

LIMESTONE FOR FLUX.

In the present depressed condition of the manufacture of iron in New York, the production of limestone for flux is but a small industry.

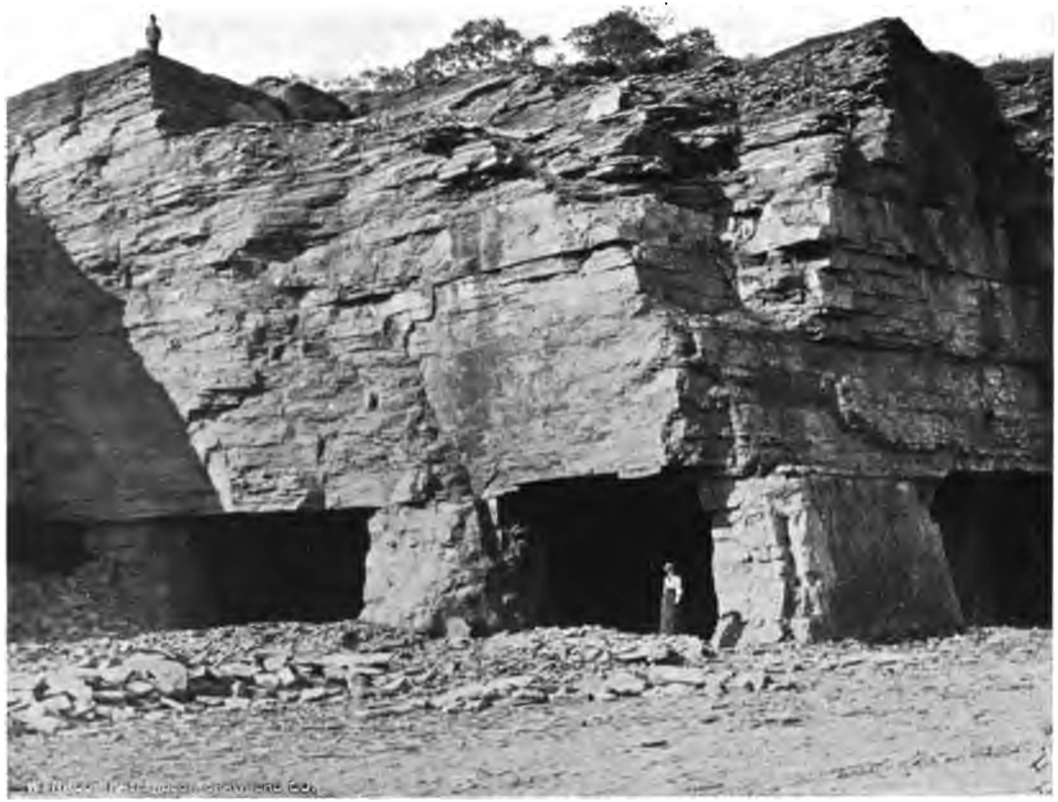
Mineral Paint

The mineral paint of New York state is from comparatively few localities, and is manufactured from rocks of five formations:

1 From Rossie iron ore.

2 From Cambrian red and green slate, near Whitehall.

PLATE CXIV.—To face page 222.



N. H. Darton, photo.

QUARRY IN TRENTON LIMESTONE, SARATOGA CO., SOUTH BANK OF HUDSON RIVER OPPOSITE GLENS FALLS.
ROCK QUARRIED FOR QUICK-LIME.

PLATE CXV.—To face page 222.

H. Ries, photo.

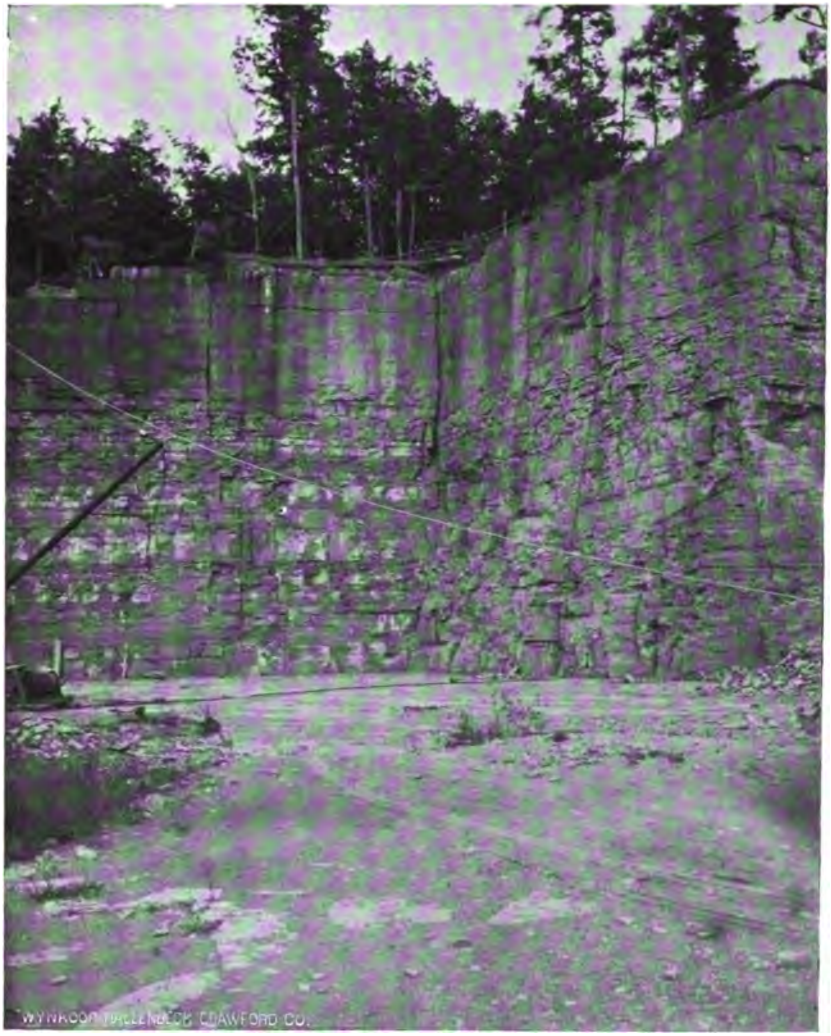
INTERIOR VIEW OF CEMENT MINE AT ROSENDALE, ULSTER CO. WATERLIME GROUP.

PLATE CXVI.—To face page 222.

N. H. Darton, photo.

CEMENT QUARRIES, ONE MILE SOUTH OF WHITEPORT, ULSTER CO. WATERLIME GROUP.

PLATE CXVII.—To face page 222.



N. H. Darton, photo.

QUARRY IN LOWER PENTAMERUS AND TENTACULITE LIMESTONE, HOWE'S CAVE, SCHOHARIE CO.

PLATE CXVIII.—To face page 222.

I. P. Bishop, photo.

QUARRY OF THE BUFFALO CEMENT CO., BUFFALO, ERIE CO.

I. P. Bishop, photo.

QUARRIES OF THE BUFFALO CEMENT CO., BUFFALO, ERIE CO. RAILWAY FOR DRAWING STONE TO THE CRUSHER.

3 From Clinton iron ore.

4 From Chemung shale, at Randolph.

5 From Catskill shale at Roxbury and Oneonta.

This material is produced as a by-product in several industries. For instance near Whitehall red and green mineral paint are produced by grinding up the refuse of the slate mills. At Clinton, Oneida county, paint is manufactured from the Clinton iron ore. At Randolph in Cattaraugus county, paint is made from red shales of the Chemung group. At Roxbury, Delaware county, paint is made from red Catskill shales and at Oneonta a similar pigment has been made.

Marl

This material is found in many places throughout the state. Dutchess, Columbia, Orange, Ulster, Greene and Albany counties have many small deposits; in central and western New York there are large deposits in Onondaga and Madison counties, particularly in the Cowaselon swamp; it is also found in Cayuga, Wayne, Seneca, Ontario, Monroe, Genesee and Niagara counties.

It is a deposit formed in standing water and consists chiefly of carbonate of lime. It is largely used as a fertilizer, but is also employed in the manufacture of Portland cement as at Warners, Onondaga county, by the Empire Portland Cement Co., at Montezuma and at Wayland, Steuben county, by Millen & Co.

Millstones

Millstones for grinding paint, feed, cement and other purposes are quarried from the Oneida conglomerate in Ulster county in the town of Rochester at Accord, Granite and Kyserike and in Wawarsing at Kerhonkson.

Salt

The salt industry of New York is of great importance. Originally Syracuse was the center of this industry, but since the discovery of rock salt in and near the Genesee valley where richer brines can be obtained than at Syracuse, the center of the industry

has been transferred to this new district and the manufacture of salt at Syracuse has gradually diminished.

The salt mines of the Retsof, Livonia and Greigsville companies produce immense quantities of salt for the beef and pork packing industries, and in this respect are not directly competitors of the companies manufacturing salt from brine. About 15 miles south of Syracuse the Solvay Process Company having found rock salt in great quantity, by boring a large number of wells and availing itself of an abundant water supply is, by the aid of gravity, enabled to bring brine in a highly saturated condition to its works at Syracuse through a pipe line. This is the basis of a very large industry in soda ash. The Solvay Company also sells brine for the manufacture of salt.

In the Genesee valley and near Warsaw and Wyoming are many salt wells. There are others at Ithaca and Watkins.

A detailed description of the salt and gypsum deposits of New York is given in Bulletin No. 11 of the New York State Museum.

Gypsum

Gypsum is quarried in New York on the outcrop of the Salina group in Madison, Onondaga, Cayuga, Ontario, Monroe and Genesee counties. It is chiefly used as a fertilizer in the form of land plaster, though at Oakfield, Genesee county, a factory has been established to utilize the gypsum in the manufacture of wall plaster.

Graphite

Graphite of excellent quality is obtained near Ticonderoga, the deposit being controlled by the Dixon Crucible Company of Jersey City. The mineral occurs in a mica schist and in crystalline limestone. It is used in the manufacture of pencils, crucibles, lubricants and for a variety of other purposes.

Quartz

This material is quarried for pottery at Bedford, Westchester county, and is shipped to Trenton, N. J. White quartzite of

Cambrian age, quarried at Fort Ann in Washington county, has been ground for use as a wood filler. It has also been used at the Troy Iron Works for lining Bessemer converters and for similar refractory purposes. A similar rock is quarried for wood filler at Billings, Dutchess county.

At Ellenville, Ulster county, quarries and mills are operated by the Crystal Sand Manufacturing Company. The product which is called 'glass sand' is obtained from the Shawangunk grit, which is crushed very fine. Much of it is sent to the glass works at Corning.

Glass Sand

Large glass sand deposits of Quaternary age occur at Durhamville, near Oneida lake. They are operated by William Williams. The sand is not as white nor as fine as that from Ellenville, and is used for the commoner grades of glassware. Much of it is shipped to Lockport. The sand contains 97–97.5% Si. O2.

Glass was formerly made at Sand Lake in Rensselaer County.

An artificial glass sand made at Ellenville is described under the previous head.

Molding Sand

Sand for molding is found in southern Albany county, near the Hudson river, immediately below the surface soil. When this is removed the sand is skimmed off to a depth of about six inches. It is quite extensively shipped from the town of Bethlehem. This is a Quaternary deposit. Near Poughkeepsie molding sand is obtained from a silicious Potsdam limestone, which, in decomposing, leaves a fine sand which has been found very satisfactory for this purpose.

Garnet

Garnet is mined or quarried in New York state in and near the valley of the upper Hudson river in Warren county on the borders of the Adirondack region. It all appears to be of the common variety, Almandite, and occurs in a formation of crystalline limestone which appears to form the bed-rock of the valley in the vicinity of North Creek and Minerva and in gneissic

rocks which adjoin, or are intercalated with, the crystalline limestone. It is found in segregated masses of varying sizes from that of a pigeon's egg to a diameter of 20 feet. It is commercially classified as massive garnet, shell garnet and pocket garnet, the former being impure from the admixture of other minerals. The shell garnet is almost entirely pure and the most valuable for industrial purposes. The pocket garnet is that which occurs in small segregations or incipient crystals in the gneiss.

This garnet is used almost exclusively in the manufacture of sandpaper, or garnet-paper, as it is called, which is employed extensively for abrasive purposes in the manufacture of boots and shoes. It is also employed to some extent in the wood manufacturing industry. For metals garnet is not as good as emery, although some satisfactory results have been obtained from its use on brass. It has been experimentally mixed with emery in the manufacture of emery-wheels but without very satisfactory results.

Emery

The variety of Corundum known as emery is quarried at many points in Cortlandt township, Westchester county, from deposits which occur in the eruptive rocks known as the 'Cortlandt series.' It is used by the New York Emery Company at Peekskill.

Diatomaceous Earth — Infusorial Earth

This material consists of hydrated silica, and is the accumulation of the minute skeletons of microscopic forms of vegetable life known as diatoms. It accumulates in the bottom of ponds and lakes, and is found in recent as well as Tertiary and Cretaceous formations. While the living diatoms are found in all the waters of the state, deposits of diatomaceous earth have been reported from only two localities. One of these is in White lake, town of Wilmurt, Herkimer county, and the other is on the shore of Cold Spring Harbor, Long Island, on the property of Dr. Oliver Jones. The latter is a fossil deposit in beds probably of Tertiary age. The White lake deposit is the only one in use

commercially at present. The material is dug from the bottom of the lake, which covers about four acres, and has a thickness of two to 30 feet, being covered by about four feet of water. It is washed and run through strainers and pipes to settling vats, where it stands for 24 hours. The water is then drawn off and the material shovelled into the press. Here it is made into cakes four feet square and four inches thick. These are subdivided into cakes one foot square and piled under sheds to dry. For this information I am indebted to the proprietor, Mr. Thomas W. Grosvenor, of Herkimer.

The White lake material is at present only used for polishing, though similar material is used for absorbing nitroglycerine in the manufacture of dynamite.

Talc

This material occurs near Edwards, St Lawrence county, N. Y., in a narrow belt several miles long and about a mile wide. There are several quarries on the line of this belt. It is ground in mills near Gouverneur under the control of the Asbestos Pulp Company. It is chiefly used in the manufacture of paper and a small quantity is used in soap, paint and other minor purposes. The annual product is about 30,000 tons, valued at about $240,000.

Peat

This material, which is the residue from the partial decay of plants in water, is of frequent occurrence, but is only used locally as a fertilizer.

Petroleum and Illuminating Gas

The occurrence of petroleum in New York was first recorded by a Franciscan friar who visited the oil spring at Cuba, Allegany county, in 1627. Late in the present century the oil from this spring was highly valued by the Indians for external applications and was thought to have a highly curative power. It was widely known under the name of 'Seneca oil.' The production of oil in New York is at present confined to Cattaraugus

and Allegany counties. The Cattaraugus county field is a northward extension of the Bradford field of Pennsylvania and is continuous over the state line. The Allegany county field is more isolated, although the oil comes from the same geological horizon, which is a sandstone in the upper Chemung or Catskill. This has been discussed in great detail by Charles A. Ashburner in the Transactions of American Institute of Mining Engineers for 1887.

Natural illuminating gas was first used in New York at Fredonia, Chautauqua county, in 1821. It is still in use at the locality in question, but the quantity is insufficient to supply the whole village. Besides Fredonia, at the present time Buffalo, Honeoye Falls, Pulaski and Sandy Creek are using natural gas for heating and illuminating purposes and wells have been bored in the vicinity of Oswego, as well as at Fulton and Baldwinsville. Gas wells have been bored tentatively at a large number of places in New York State and small quantities of gas have been found, but the enterprises have not been financially successful. At present many of the wells in Buffalo have ceased to yield and a large quantity of the natural gas now consumed in that city is brought in pipe-lines from Canada. The gas of Fredonia comes from shales immediately over the corniferous limestone. The gas of the oil districts comes, like the oil, from the horizon of the Catskill. The gas of central and northern New York comes from the Trenton limestone.

Natural Carbonic Acid Gas

This material is obtained at Saratoga Springs and vicinity by boring wells to a depth of about 350 feet. Carbonated waters flow to the surface and are conducted through pipes to large gas holders, where the gas separates from the water and is then pumped into compressors from which it is forced into steel cylinders under a pressure of about 1,000 pounds to the square inch. These cylinders, when filled, are shipped to the consumers, who use it chiefly in the manufacture of soda water, both for the wholesale and retail trades. At present this gas is shipped from

Saratoga Springs to New York. New Jersey, Pennsylvania, Massachusetts, Connecticut and Rhode Island. In addition to the large quantities consumed for soda water, it is also being used for refrigerating purposes and in the manufacture of cod liver oil.

Mineral Waters

The mineral springs of New York are widely known. In addition to the revenue from mineral springs used for baths at health resorts, a large industry now exists in the bottling and shipment of mineral waters for domestic consumption.

List of Mineral Springs in New York which are Commercially Productive

Adirondack Mineral Springs (H. V. Knight), Whitehall, Washington county.

Avon Sulphur Springs (O. D. Phelps), Avon, Livingston county.

Artesian Lithia Spring (C. O. McCreedy), Ballston Spa, Saratoga county.

Cairo White Sulphur Spring (H. K. Lyon), Cairo, Greene county.

Cayuga Mineral Spring (Lucius Baldwin), Cayuga, Cayuga county.

Chittenango White Sulphur Springs (W. H. Young), Chittenango, Madison county.

Chlorine Springs (J. L. Grover), Syracuse, Onondaga county.

Clifton Springs (Dr. Henry Foster), Clifton Springs, Ontario county.

Dansville Springs (J. Arthur Jackson, secretary and manager), Dansville, Livingston county.

Deep Rock Spring (Deep Rock Spring Co.), Oswego, Oswego county.

Massena Springs (Shedden & Stearns), Massena, St. Lawrence county.

Nunda Mineral Springs (Daniel Price), Nunda, Livingston county.

Reid's Mineral Spring (J. R. McNeil), South Argyle, Washington county.

Richfield Springs (T. R. Proctor), Richfield Springs, Otsego county.

Champion Spring (J. Z. Formel), Saratoga Springs, Saratoga county.

Empire Spring (H. W. Hayes, manager), Saratoga Springs, Saratoga county.

Excelsior Spring (F. W. Lawrence), Saratoga Springs, Saratoga county.

Geyser Springs (Geyser Spring Co.), Saratoga Springs, Saratoga county.

Hathorn Spring (Hathorn Spring Co.), Saratoga Springs, Saratoga county.

Old Red Spring (E. H. Peters, superintendent), Saratoga Springs, Saratoga county.

Vichy Springs (L. A. James, superintendent), Saratoga Springs, Saratoga county.

Sharon Springs (John H. Gardner & Son), Sharon Springs, Schoharie county.

Slaterville Magnetic Springs (W. J. Carns & Son), Slaterville, Tompkins county.

Verona Mineral Springs (A. A. Hunt, M. D.), Verona, Oneida county.

White Sulphur Springs (T. C. Luther), Ballston Spa, Saratoga county.

White Sulphur Springs (J. Hochstatter), Berne, Albany county.
Star Springs, Saratoga Springs.

Elkhorn Spring (Clark Snook), Manlius.

Royal Spring (A. Putnam, Jr., president), Saratoga Springs, Saratoga county.

Lebanon Thermal Spring (P. Carpenter), Lebanon Springs.

Crystal Rock Water Co. (L. G. Deland, president), Fairport.

Victor Spring (H. J. Dickinson, Buffalo), Darien, Genesee county.

Geneva Magnetic Mineral Spring (C. A. Steele), Geneva, N. Y., Ontario county.

Oneita Springs (Oneita Spring Co.), Utica, N. Y., Oneida county.

Empire Seneca Spring (M. W. Cobb, of Fredonia), Dunkirk, N. Y., Chautauqua county.

Crystal Spring (Asa D. Baker), Barrington, N. Y., Yates county.

Great Bear Spring, Fulton, Oswego county.

Minerals Not Commercially Important

In addition to the minerals which have already been mentioned there are many deposits in New York which are not at present of commercial importance. These may be roughly classified as metallic minerals and non-metallic minerals.

METALLIC MINERALS

In this class are iron pyrites, arsenopyrite, chromite, chalcopyrite, cuprite, galenite, cerusite, sphalerite, wad or bog manganese, millerite and molybdenite. The galenite and pyrites have respectively yielded small quantities of silver and gold at certain places, but *at no locality in New York have enough of the precious metals been found at any time to pay for the expense of extracting them.* From time to time capital is invested for the purpose of gold or silver mining in New York, but always without practical results. The experience of 50 years has shown that neither in New York nor in New England have either of the metals been found in paying quantities.

The following is a list of the principal localities at which the various metallic minerals are found:

IRON, SULPHUR, ARSENIC

Pyrite, iron pyrites, bisulphide of iron. Anthony's nose, Westchester county, mine formerly worked; Philips ore bed, Phillipstown, Patterson, southeast of Carmel and near Ludington mills, in Putnam county; with galena at Wurtsboro lead mine, Sullivan county; Flat creek, Montgomery county; near Canton, St Lawrence county, in extensive beds; Duane, Franklin county, large bed; Martinsburg, Lewis county; Eighteen-mile creek, Erie county, and many other localities, sparingly in rocks.

Arsenopyrite, mispickel. Near Edenville, Orange county, with arsenical iron and orpiment, in a vein in white limestone; near Pine pond in Kent, and near Boyd's Corner, Putnam county. These localities have been opened, but not worked for arsenic.

Chromite, chrome iron ore. In serpentine, Phillipstown, Putnam county; Wilks' mine, Monroe, Orange county.

COPPER

Chalcopyrite, copper pyrites; sulphide of iron and copper. Ancram lead mine, Columbia county; Bockee mine, Columbia county; near Edenville, Orange county; with arsenopyrite; near Wurtsboro, Sullivan county, with galena in considerable abundance; Ellenville and Red Ridge lead mines, Ulster county; near Rossie, and also near Canton, in St Lawrence county, once worked. Many additional occurrences are reported where it is in small quantity.

Cuprite, red oxide of copper. Near Ladentown, Rockland county, in thin seams, in trap rock.

LEAD

Galenite, galena; sulphide of lead. Otisville, Orange county; Ellenville and Red Bridge, Ulster county; with copper pyrites and blende, in a gangue of quartz in Oneida conglomerate, mines no longer worked; Wurtsboro, Sullivan county; near Sing Sing, in Westchester county; northeast township, Dutchess county; Ancram, Columbia county; strings of galena, blende and pyrites in limestone; White creek, Washington county; Martinsburg, Lewis county; Spraker's basin, Montgomery county; Rossie and vicinity, St Lawrence county; *mines largely worked years ago;* ore occurs in vein with blend, pyrites and copper pyrites. These mines have all been idle for several years.

Cerusite, carbonate of lead. Rossie, Robinson, Ross and other lead mines, in St Lawrence county; Martinsburg, Lewis county; near Sing Sing, on Hudson, associated with galena, in small quantity.

ZINC

Sphalerite, zinc blende; sulphide of zinc. Associated with galena at lead mines in Sullivan, Ulster and Orange counties; Ancram, Columbia county; Flat creek, Montgomery county; Salisbury, Herkimer county; Martinsburg, Lewisburg, Lewis county; Cooper's Falls, Mineral Point, and in Fowler, St Lawrence county.

MANGANESE

Wad, earthy manganese, bog manganese. In town of Austerlitz, Columbia county, are several localities; also in Hillsdale and Canaan, same county; smaller deposits near Houseville, Lewis county, and southeast of Warwick, Orange county.

NICKEL

Millerite, sulphide of nickel. Sterling iron mine, Antwerp, Jefferson county, famous for crystalline forms.

MOLYBDENUM

Molybdenite; sulphide of molybdenum. West Point and near Warwick, Orange county; Philips mine, Putnam county; Clinton county, but sparingly, in granite rocks.

NON-METALLIC MINERALS

Under the head of non-metallic minerals which have a commercial value but do not occur in New York in a quantity large enough to be of economic importance, may be enumerated apatite, asbestus, barite, biotite, calcite, fluorite, magnesite, muscovite and serpentine. The principal localities for these minerals are given herewith:

Apatite; phosphate of lime. Hammond, St Lawrence county, crystalline, with calcite, zinc ore and feldspar; near Gouverneur, St Lawrence county, crystals in calcite, Vrooman lake, Jefferson county; Greenfield, Saratoga county; near Hammondsville, Essex county; with magnetite in some of iron ores near Port Henry; other localities of occurrence.

Barite, barytes, heavy spar; sulphate of baryta. Ancram, Columbia county; near Schoharie Courthouse, with strontianite, in the

Water-lime group; Carlisle, Schoharie county; near Littlefalls and Fairfield, Herkimer county; near Syracuse, Onondaga county; Pillar Point, Jefferson county, in large veins; Hammond and De Kalb, St Lawrence county.

Calcite, calcareous tufa, travertine; carbonate of lime. Vicinity of Schoharie Courthouse, Schoharie county; Sharon Springs, a large deposit; Howe's Cave, Schoharie county; near Catskill, Greene county; head of Otsquaga creek, Stark, Herkimer county; Saratoga Springs; near Syracuse and in Onondaga valley, Onondaga county; between Camillus and Canton, same county; near Arkport, Steuben county; near Ellicott's mills, Erie county, and many lesser deposits.

Fluorite, fluor spar; fluoride of lime. Muscalonge lake, Alexandria, Jefferson county, very fine crystals; Lowville, Lewis county; Niagara county, at Lockport; Auburn, Cayuga county; Rossie and Mineral Point, St Lawrence county.

Magnesite, carbonate of magnesia. Near Rye, Westchester county; Warwick, Orange county; New Rochelle, Westchester county; Stony Point, Rockland county; Serpentine hills, Staten Island; everywhere in thin seams and strings.

Muscovite, mica. As a rock constituent, common. In large plates near Warwick and at Greenwood at Mount Bashan pond, in Orange county; Pleasantville, Westchester county, once opened and mined; Henderson, Jefferson county; Potsdam and Edwards, in St Lawrence county.

Serpentine. Staten Island, near New Rochelle and near Rye, Westchester county; Phillipstown, Putnam county; near Amity, Orange county, verd antique; Johnsburg and Warrensburg, Warren county; Shelving rock, Lake George, Washington county; Gouverneur, Fowler, Edwards and Pitcairn townships, in St Lawrence county; other localities of occurrence in small quantity.

COAL AND LIGNITE

Coal and lignite, while they occur in New York, can never be found in commercial quantities. The coal measures of Pennsylvania are not found north of the boundary line between Pennsyl-

vania and New York, and what coal has been discovered in the latter state is in older formations which do not contain this valuable mineral in commercial quantities. Many thousands of dollars have been spent in fruitless efforts to obtain coal in New York, but year after year men appear in the field who seem anxious to pay for their own experience. It can not be too strongly urged upon the attention of the people of the state that *it is absolutely useless to seek for coal in New York.*

Coal. Woodstock, Ulster county, thin vein in the Catskill, worked out; in seams interstratified with shale, in Chautauqua, Erie, Livingston and Seneca counties.

Lignite, brown coal. Near Rossville, Staten Island, thin seam in clay; also in Suffolk county in clays.

PART 4.

SUGGESTIONS FOR STUDY

GEOLOGIC TEXT-BOOKS AND BOOKS OF REFERENCE

Geology is not, like history, a subject which can be learned wholly from books. Not even an elementary knowledge of it can be readily obtained without careful field study of some prominent district. The student must, however, use books to supply him with information as to the work of others who have gone before, while his powers of observation and inference are being trained on geologic phenomena.

When taking up the field study of a new district, it is important to ascertain what is already known concerning it. An attempt is made, therefore, to direct attention to the principal publications on New York geology.

The four geologic reports of Hall, Mather, Emmons and Vanuxem on the districts assigned to them in the original survey of the state which was begun in 1837 and concluded in 1841, are now out of print, but are found in most of the public libraries of New York, and can be purchased of the dealers in old books in the larger cities. They contain an immense amount of valuable detail and should be consulted by all persons interested in New York geology. The report on the fourth district by James Hall, is as valuable to-day as when it was written and comparatively little has been added by later investigators in the region described, except in regard to quaternary and economic geology.

In addition to these four quarto volumes on the geology of New York, there have been many papers published in the annual reports of the New York State Museum and the State Geologist of New York. A multitude of papers have also been published by persons not officially connected with the State

In addition to the more technical books described above, there are many accurate and important works written for popular reading both at home and abroad. The number of these is constantly increasing and they can be found in the large libraries or obtained through the book sellers.

Field Work

OUTCROPS

There are in general two classes of geologic strata, the hard and the soft. In New York the hard strata include all rocks older than the Cretaceous. The soft include the formations of the Cretaceous, Tertiary and Quaternary. Almost everywhere the hard rocks are overlaid by soft deposits, usually of Quarternary age, so that in any locality there is generally both hard and soft geology.

The hard geology is probably best for the beginner to take up first, where he has a choice between the two. In Dana's *Manual of Geology* and Sir Archibald Geikie's *Outlines of Field Geology*, detailed directions are given for methods of study among the hard rocks.

The most important habit to be cultivated by the beginner in geology, is that of recognizing outcrops when they occur, or in their absence, of determining by surface indications the character of the rock which underlies the soil.

The beginner must form early, the habit of distinguishing loose fragments or boulders from ledges or outcrops, and in regions devoid of outcrops must study carefully the stone fences for fragments of the local rock. The fences as a rule represent the aggregate of loose rock fragments gathered from the surface of the agricultural lands and these fragments have usually come from the underlying rock. In parts of western New York, over the soft Salina shales no fragments of local rock are found because it decomposes into clay. There the fences are formed of small, hard cobblestones chiefly derived from the granite and gneiss rocks of Canada and brought to their present resting place by the great ice sheet.

Where the covering of soil and other loose material is thick, outcrops should be sought along the beds of rivers, creeks and rivulets. Running water usually cuts through the softer material and reaches the harder rock below. For this reason the gutters and ditches by the sides of roads should be examined for exposures, if no other source of information is available.

It is not possible here to give any adequate directions for the study of soft geology. This branch is still immature and is chiefly in the hands of specialists. The literature of Quaternary geology is, however, very large and by a careful study of it, the beginner may form some conception of its scope. A single field day with a good geologist is worth more than many weeks of reading.

FOSSILS

It is important for the beginner to realize that perfect specimens of fossils such as are exhibited in the museums and figured in the works on palaeontology are not every where to be found and that the more common examples are fragmentary. Were it not for the dissolving action of atmospheric water on carbonate of lime the study of fossils would still be in its infancy, as in many cases the fossil is wholly inclosed in a firm mass of limestone from which it can not be separated by the hammer alone. On the surface exposures of limestone, the action of the weather removes a part of the matrix, exposing for a time the surface of the shell. This after a few years may in turn yield to the dissolving action of atmospheric water and gradually disappear, another specimen at a lower level being gradually brought to view in its place. In sandstones, the calcareous fossils are usually entirely dissolved out of the surface layers and it is only by the impressions or casts which they leave behind, that we know of their existence. If means are afforded for excavation and blasting, below the reach of the rain water, will be found a bed of rock from which the calcareous matter has not been dissolved away, but in this case it is often difficult to separate the fossils except by long and tedious process of cleaning or developing with small tools.

Within the writer's observation, students at the beginning of their field experience are misled by the perfection of cabinet specimens and figures and hope to find everywhere such perfect forms; as a matter of fact, they must learn to be guided for the most part by fragments.

It does not seem possible to give within the limits of this publication any adequate description of the fossils which are characteristic of the different strata. It is better for these to refer to the original publications of the New York Natural History Survey. In the four reports on geology by Mather, Emmons, Vanuxem and Hall, numerous illustrations of fossils are given but the names are, in many cases, out of date. In the volumes on Palaeontology from I to VII, are described and figured most of the fossils of New York state from the Potsdam sandstone to the Chemung. Volume VIII gives a revision of the Brachiopoda. To these volumes, therefore, the student should refer for the identification of such forms as he may find in his field excursions. A few of the more common species are figured in Dana's *Manual of Geology*, which should be in the hands of every student. For those pursuing more critical studies, the work of S. A. Miller on *North American Geology and Palaeontology* is of great value as it gives a complete list of all Palaeozoic fossils described up to the date of its publication and indicates the more modern names in the many cases where there has been a change of nomenclature. Of the eight volumes of New York palaeontology mentioned, the first two are out of print and are only to be had from dealers in second hand books, but they will probably be found in most of the public libraries of New York state. The remaining volumes are sold at $2.50 each.

THE NATURAL HISTORY SURVEY OF NEW YORK AND THE ORIGIN OF THE STATE MUSEUM

The New York State Museum, organized by act of legislature in 1870 under the title of the State Museum of Natural History and placed under the trusteeship of the Regents of the University, is the result of the geological survey of the state commenced in 1836.

This survey was established at the expressed wish of the people to have some definite and positive knowledge of the mineral resources and the vegetable and animal productions of the state.

Hon. Stephen Van Rensselaer was the patron of the first enterprise of this kind, and had published much valuable information, but it was felt that a more thorough investigation was needed. The idea was fully expressed in a memorial presented by the Albany Institute to the state legislature in 1834, in which the object was thus stated: 'to form a grand and comprehensive collection of the natural productions of the state of New York; to exhibit at one view, and under one roof, its animal, vegetable and mineral wealth.'

In 1835 the New York Lyceum of Natural History presented a memorial to the legislature on the same subject, and it is presumed that this memorial and the influences prompting the request of the Albany Institute, induced the legislature of 1835 to pass a resolution requesting the secretary of state to report to that body a plan for 'a complete geological survey of the state, which should furnish a scientific and perfect account of its rocks, soils and minerals; also a list of its mineralogical, botanical and zoological productions, and provide for procuring and preserving specimens of the same, etc.'

Pursuant to this request, Hon. John A. Dix, then secretary of state, presented to the legislature of 1836, a report proposing a plan for a complete geological, botanical and zoological survey of the state.

The scientific staff of the natural history survey of 1837 was appointed by Governor Seward pursuant to an act of the legislature, and consisted of John Torrey, botanist, James E. De Kay, zoologist, Lewis C. Beck, mineralogist, W. W. Mather, Ebenezer Emmons, Lardner Vanuxem and James Hall, geologists, and Timothy A. Conrad, paleontologist. The state was divided into four districts, each of which was assigned to a geologist in the order given.

The heads of the several departments reported annually to the governor the results of their investigations, and these constituted

the annual octavo reports which were published from 1837 to 1841. The final reports were published in quarto form, beginning at the close of the field work in 1841, and 3,000 sets have been distributed, comprising four volumes of geology, one of mineralogy, two of botany, five of zoology, five of agriculture and eight of palaeontology.

The collections in the several departments were supposed to require a room of some magnitude, and it was thought that such could be found in the third story of the old capitol, by taking away a partition and throwing into one, two rooms used by committees; but long before the completion of the survey it was evident that the collections would require much more space than the capitol rooms would afford, and in 1840 Gov. Seward, in response to a memorial urging 'the importance of providing suitable rooms or a separate building for the collections made during the survey,' recommended that the old State hall on the corner of State and Lodge streets be used for that purpose.

This old building was replaced in 1857 by a new one, Geological and Agricultural hall, and the collections which at first were to find place in two committee rooms, now occupy a large part of the main floor and three entire floors above, besides storage accommodations in the basement.

These collections form a scientific museum of great interest and value, and its publications are recognized among the works of standard authority in science. The geological survey of New York has been comprehensive and extended, yet some portions of the work are still incomplete; the northern part of the state has been but partially studied, and its geologic structure is but imperfectly known.

This museum, with its extensive and increasing collections and publications, plays an important part in the educational system of the state, since the importance of this kind of education has become so fully and generally recognized.

Although neither coal nor mines of gold or silver have been found within the state, it has been shown that New York possesses the most complete and unbroken series of the Palaeozoic

or older fossiliferous rocks known in the world; and that for these the collections of the museum with the nomenclature adopted by the geological survey of New York will always be the standard of reference and authority.

It may justly be said that Hon. John A. Dix, as secretary of state, in 1836 laid the foundation of this museum and of all the scientific and practical results which have accrued from the inauguration of the geological survey of the state of New York.

At the time of the final arrangement of the collections of the geological survey, in 1843, very little was known in this country regarding museums of natural history, and no true appreciation of what such an institution should be, existed, except in the minds of a few persons. It is not strange, therefore, that there should have been a general acquiesence in the proposition that the collections of the geological survey should be deposited in the old State hall for 'safe keeping,' and the idea of constant and steady increase toward a great museum of natural history was scarcely, if at all promulgated. The collections and the rooms that they occupied were placed in charge of a curator, Mr. J. W. Taylor, who was succeeded by Mr. John Gebhard, Jr, and he in turn in 1857 by Colonel Jewett. The small annual appropriations made by the legislature were only sufficient for the custody and very moderate increase of the collection. Matters remained in this condition till 1865, when the legislature passed some resolutions tending to the expansion of the museum; and, following these, the secretary of the board of regents addressed a circular letter to numerous scientific men, professors and teachers, asking suggestions as to the best mode of putting in force the objects of the legislature as expressed in the resolutions referred to.

The communications in reply to this were published in the 19th report of the State Cabinet, together with a recommendation of the committee of the regents to whom the subject had been referred. This recommendation became the first step toward an improved condition, and a recognition of the necessity of regarding the museum as a series of collections in natural history which were to be increased and elaborated in every de-

partment. In 1865 Col. Jewett resigned and was succeeded by James Hall.

The discovery of the mastodon skeleton at Cohoes, in the summer of 1866, and its acquisition by the State Cabinet, attracted much attention toward the institution. At the next legislature successful application was made for $5,000 to purchase the Gould collection of shells and this accession of 60,000 specimens representing 6,000 species was generally appreciated.

The new capitol commissioners, wishing information as to the sources of building material, engaged the curator of the State Cabinet to make a reconnaissance which resulted in a report to the commissioners, and the acquisition to the State Cabinet, by this and other means, of a large collection of marbles, limestones, sandstones and granites which are now included in the collection which occupies two sides of the entrance hall of the museum.

At first the State Cabinet received no regular or fixed appropriation of money from the legislature, but in 1870 a law was passed organizing the same, under the designation of the State Museum of Natural History, and appropriating $10,000 annually to provide for the salaries of the director and three assistants, together with the expenses of increase and preservation of the collections. In addition to this, a sum was annually appropriated for the salary of a botanist, and special appropriations have been made from time to time.

In 1881 a state entomologist was appointed and in 1883 was made a member of the museum staff.

The present appropriation of $12,000 is quite inadequate to the requirements of such a museum, but a visible and substantial progress is made in each of the departments, as shown in the increasing order and the additions to the collections, as recorded in the annual museum reports.

In 1889 the State Museum was made an integral part of the University of the State of New York. In 1894 the present director was appointed. Most of the museum remains on the four floors of Geological hall on State street, at the corner of Lodge. Here are the collections in mineralogy, geology, palaeontology, zoology and ethnology and the offices of the director and his assistants. The state geologist and palaeontolo-

gist and his staff have their offices in State hall in Eagle street, and the entomologist and botanist are in the north east section of the fourth floor of the capitol. The State Museum in addition to its work of collecting material representative of the natural resources of the state, is also the seat of the geologic and natural history survey which has been in progress since 1832, and under the auspices of which numerous reports have been published on geology, palaeontology, zoology and botany. The museum is open to the public from 9 a. m. till 5 p. m. daily except on Sundays and other holidays.

Inasmuch as the State Museum comprises all scientific work intrusted to the regents it is proper to mention the resurvey of the boundary line between New York and the states of New Jersey and Pennsylvania. This was done in accordance with resolutions passed by the legislature in 1867 and in 1875, and by the laws of 1880 the boundary lines resurveyed and monumented under the direction of the regents were accepted as the true boundaries of the state.

OFFICERS OF THE STATE MUSEUM

Administrative division

Frederick J. H. Merrill, Ph. D. (Columbia)............Director
A. G. Richmond..............Honorary curator in archaeology
J. N. Nevius.......................................Assistant
Joseph Morje...Page

Research division

†James Hall, M. A. (Rensselaer polytechnic) LL. D. (Harvard)
State geologist and paleontologist
Charles H. Peck, M. A. (Union)....................State botanist
*J. A. Lintner, Ph. D. (N. Y.)...............State entomologist
John M. Clarke, M. A. (Amherst)
Assistant state geologist and paleontologist

Philip Ast..........................Lithographer	Geologist's assistants	
George B. Simpson....................Draftsman		
Martin Sheehy........................Messenger		
Jacob Van Deloo...........................Clerk		

Ephraim Porter Felt, B. S. (Boston) Sc. D. (Cornell)
Entomologist's assistant

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* Died May 5, 1898.
† Died August 7, 1898.

INDEX

The superior figure shows the exact place on the page in ninths; e. g. 121^{7} means seven-ninths of the way down page 121.

Index to plates in geologic order.

Igneous.

Archaean or Precambrian.

Cambrian.

Lower Silurian.

Upper Silurian.

Devonian.

Triassic.

Quaternary.

Economic.

New York State Museum

PUBLICATIONS

Museum reports. New York state museum. Annual report 1847 — date. pl. O. Albany 1848—date.

Average 250 pages a year. *Price for all now in print, 50 cents a volume in paper; 75 cents in cloth.*

Museum bulletins. University of the State of New York. State museum bulletin. v. 1–5, O. Albany 1887 — date. *Price to advance subscribers 75 cents a year.*

Volume 1. 6 *nos. Price $1 in cloth.*

Bulletins of this volume are paged independently.

1 Marshall, W: B. Preliminary list of New York unionidae. 19p. March 1892. *Price 5 cents.*

2 Peck, C: H. Contributions to the botany of the state of New York. 66p. 2 pl. May 1887. *Out of print.*

3 Smock, J: C. Building stone in the state of New York. 152p. March 1888. *Out of print.*

4 Nason, F: L. Some New York minerals and their localities. 19p. 1 pl. Aug. 1888. *Price 5 cents.*

5 Lintner, J. A. White grub of the May beetle. 31p. il. Nov. 1888. *Price 10 cents.*

6 Lintner, J. A. Cut-worms. 36p. il. Nov. 1888. *Price 10 cents.*

Volume 2. 4 *nos. Price $1 in cloth.*

7 Smock, J: C. First report on the iron mines and iron ore districts in the state of New York. 5+70p. map 58×60 cm. June 1889. *Price 20 cents.*

8 Peck, C: H. Boleti of the United States. 96p. Sep. 1889. *Price 20 cents.*

9 Marshall, W: B. Beaks of unionidae inhabiting the vicinity of Albany, N. Y. 23p. 1 pl. Aug. 1890. *Price 10 cents.*

10 Smock, J: C. Building stone in New York. 210p. map 58 × 60 cm, tab. Sep. 1890. *Price 40 cents.*

Volume 3

11 Merrill, F: J. H. Salt and gypsum industries in New York. 92p. 2 maps 38×58, 61×66 cm, 11 tab. 12 pl. April 1893. *Price 40 cents.*

12 Merrill, F: J. H. & Ries, H. Brick and pottery clays of New York state. 167p. 1 map 59×67 cm. 2 pl. March 1895. *Price 30 cents.*

13 Lintner, J. A. Some destructive insects of New York state; San José scale. 52 p. 7 pl. April 1895. *Price 15 cents.*

14 Kemp, J. F. Geology of Moriah and Essex townships, Essex co. N. Y., with notes on the iron mines. 38p. 2 maps 30×33, 38×44 cm. 7 pl. Sep. 1895. *Price 10 cents.*

15 Merrill, F: J. H Mineral resources of New York. 224p. 2 maps 22×35, 58×65cm. Feb. 1896. *Price 40 cents.*

Volume 4

16 Beauchamp, W: M. Aboriginal chipped stone implements of New York. 86p. 23 pl. Oct. 1897. *Price 25 cents.*

17 Merrill, F: J. H. Road materials and road building in New York. 48p. 2 maps 34×44, 68×92 cm. 14 pl. Oct. 1897. *Price 15 cents.*

18 Beauchamp, W: M. Polished stone articles used by the New York aborigines. 104p 35 pl. Feb. 1898. *Price 25 cents*

19 Merrill, F: J. H. Guide to the study of the geological collections of the New York state museum. 156p. 119 pl. 1 map. Nov. 1898. *Price 40 cents.*

Volume 5

20 Felt, E. P. Elm-leaf beetle. 45p. 5 pl. July 1898. *Price 5 cents.*

21 Kemp, J. F. Geology of the Lake Placid region. 24p. 1 map 31×86 cm. 1 pl. Sep. 1898. *Price 5 cents.*

22 Beauchamp, W: M. Earthenware of the New York aborigines. 78p. 33 pl. Oct. 1898. *Price 25 cents.*

Economic map. Merrill, F: J. H. Economic map of the state of New York. 59×67 cm. 1894. *Price, unmounted* 25 *cents, backed on muslin* 75 *cents, mounted on rollers* 75 *cents.*

Scale 14 miles to 1 inch.

Museum memoirs. University of the State of New York. Memoirs of the New York state museum. v. 1, Q. Albany 1889.

Uniform with the paleontology.

1 Beecher, C: E., & Clarke, J: M. Development of some Silurian brachiopoda. 95p 8 pl. Oct. 1889. *Price* 80 *cents.*

Natural history. New York state. Natural history of New York. 30 v. il. pl. maps, Q. Albany 1842–94.

Divisions 1–5 out of print.

Division 1 De Kay, J. E. Zoology. 5 v. pl. 1842–44.
" 2 Torrey, John. Botany. 2 v. 1843.
" 3 Beck, L. C. Mineralogy. 24+536p. il. pl. 1842.
" 4 Mather, W: W.; Emmons, Ebenezer; Vanuxem, Lardner; and Hall, James. Geology. 4 v. pl. maps. 1842–43.
" 5 Emmons, Ebenezer. Agriculture. 5 v. il. maps. 1846–54.

Division 6 Paleontology. Hall, James. Paleontology of New York. il. pl. sq. Q. Albany 1847 — date. *Bound in cloth.*

v. 1 Organic remains of the lower division of the New York system. 23+338p. 99 pl. 1847. *Out of print.*

v. 2 Organic remains of the lower middle division of the New York system. 8+362p. 104 pl. 1852. *Out of print.*

v. 3 Organic remains of the Lower Helderberg group and the Oriskany sandstone. pt 1, text. 12+532p. 1859. *Price* [$3.50.]

——— ——— pt 2, 143 pl. 1861. *Price* $2.50.

v. 4 Fossil brachiopoda of the Upper Helderberg, Hamilton, Portage and Chemung groups. 11+1+428p. 69 pl. 1867. *Price* $2.50.

v. 5, pt 1 Lamellibranchiata 1. Monomyaria of the Upper Helderberg, Hamilton and Chemung groups. 18+268p. 45 pl. 1884. *Price* $2.50.

——— ——— Lamellibranchiata 2. Dimyaria of the Upper Helderberg, Hamilton, Portage and Chemung groups. 62+293p. 51 pl. 1885. *Price* $2.50.

——— pt 2 Gasteropoda, pteropoda and cephalopoda of the Upper Helderberg, Hamilton, Portage and Chemung groups. 2 v. 1879. v. 1, text, 15+492p. v. 2, 120 pl. *Price* $2.50 *for* 2 *v.*

v. 6 Corals and bryozoa of the Lower and Upper Helderberg and Hamilton groups. 24+298p. 67 pl. 1887. *Price* $2.50.

v. 7 Trilobites and other crustacea of the Oriskany, Upper Helderberg, Hamilton, Portage, Chemung and Catskill groups. 64+236p. 46 pl. 1888. Cont. supplement to v. 5, pt 2. Pteropoda, cephalopoda and annelida. 42p. 18 pl. 1888. *Price* $2.50.

v. 8, pt 1 Introduction to the study of the genera of the paleozoic brachiopoda. *Price* $2.50.

——— pt 2 Paleozoic brachiopoda. 16+394p. 84 pl. 1894. *Price* $2.50.

Errata

Page	133,	line	14,	"Equisetæ"	should	read	"Equiseta."
"	136,	"	1,				
"	136,	"	2,	"periods"	"	"	"eras."
"	136,	"	18,				
"	136,	"	13,	"Keeweenawan"	"	"	"Keweenawan."
"	137,	"	12,	"Synopsis"	"	"	"Synopsis of Palaeozoic strata."
"	138,	"	40,	"latter"	"	"	"former."
"	141,	"	17,	"Keeweenaw"	"	"	"Keweenaw."
"	142,	"	3,	"equisetæ"	"	"	"equiseta."
"	140,	"	9,	"masses"	"	"	"mass."
"	142,	"	32,	"Dikelocephalus"	"	"	"Dikellocephalus."
"	146,	"	10,	"Ostracoids"	"	"	"Ostracods."
"	151,	"	15,	"Lower Silurian"	"	"	"Upper Silurian."
"	151,	"	24,	"Blue Ridge"	"	"	"Blue Mountain."
"	158,	"	10,	"equisetæ"	"	"	"equiseta."
"	163,	"	20,	"Hamilton group"	"	"	"Hamilton stage."
"	163,	"	25,	" "	"	"	"Hamilton shale."
"	170,	"	17,	"equisetæ"	"	"	"equiseta."
"	200,	"	11,	"may"	"	"	"many."
"	229,	"	11,	"Commerciall"	"	"	"Commercially."
"	238,	"	12,	"Quarternary"	"	"	"Quaternary."